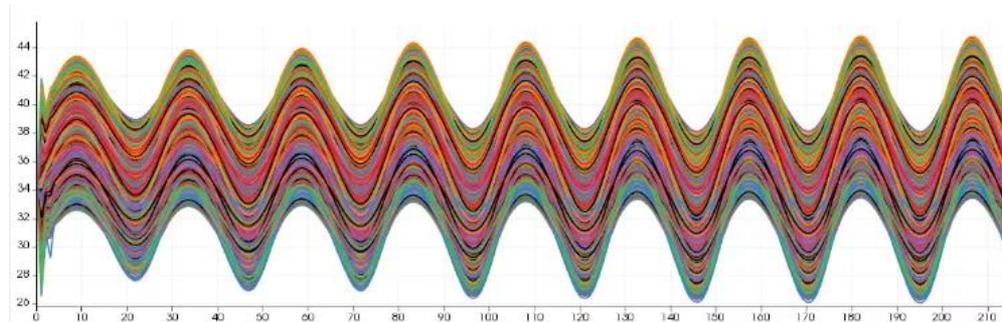


Large Scale Visualization with ParaView

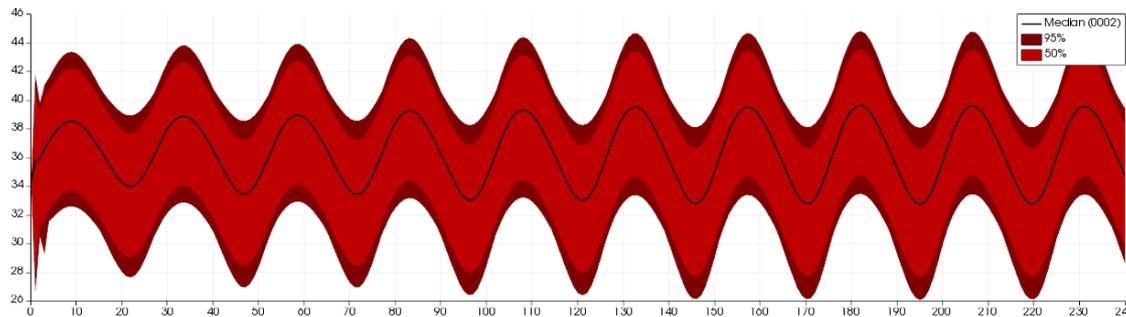
ATPESC 2020

Dan Lipsa, Staff R&D Engineer,
Kitware, Inc.

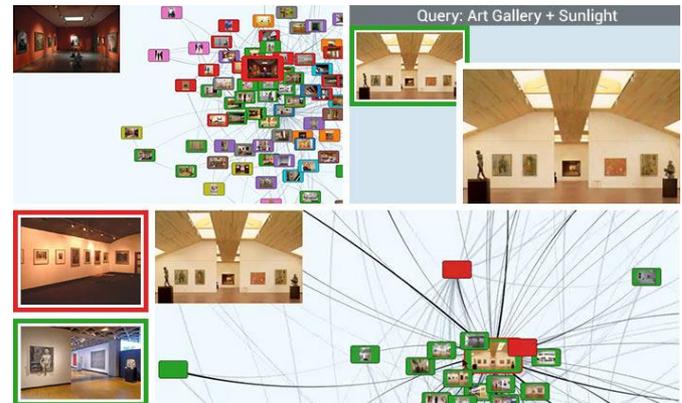
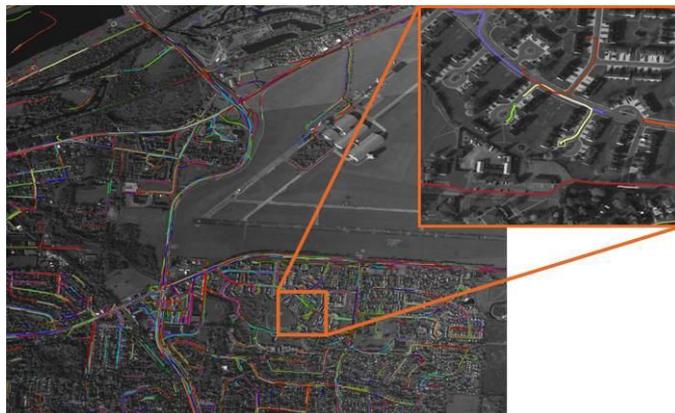
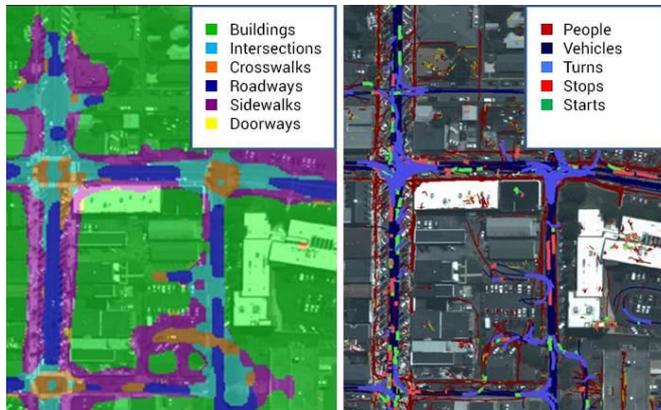


Outline

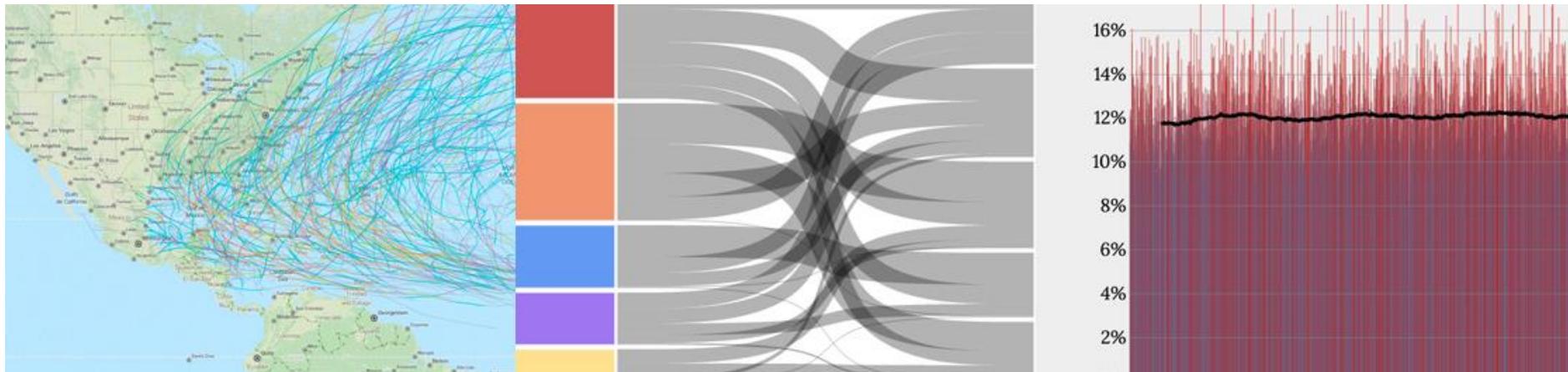
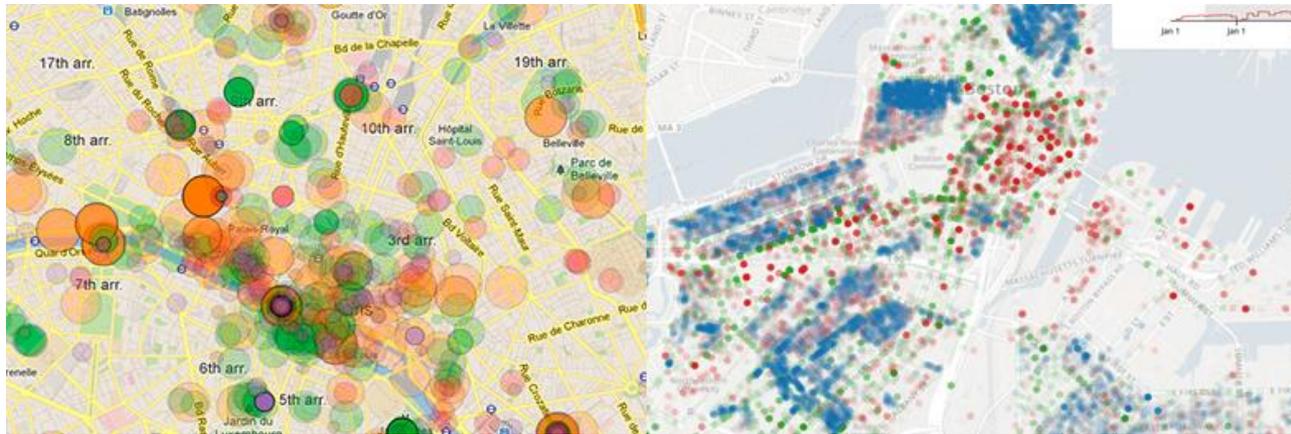
- Kitware
- Introduction
- Basic Usage
- Visualizing Large Models



Kitware – Computer Vision

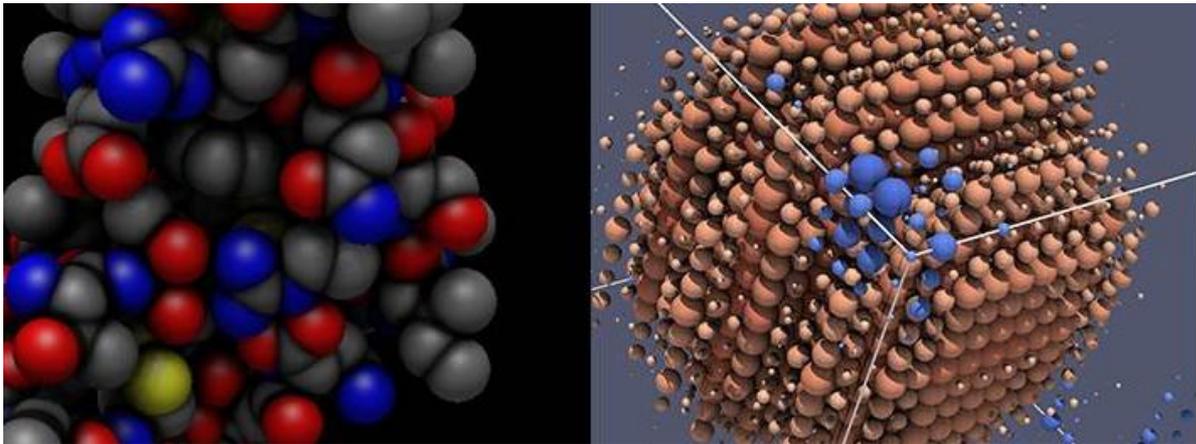


Kitware – Data and Analytics

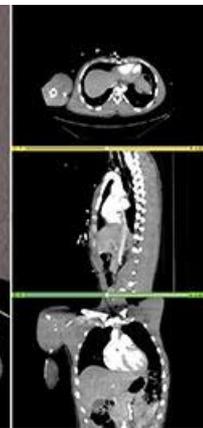
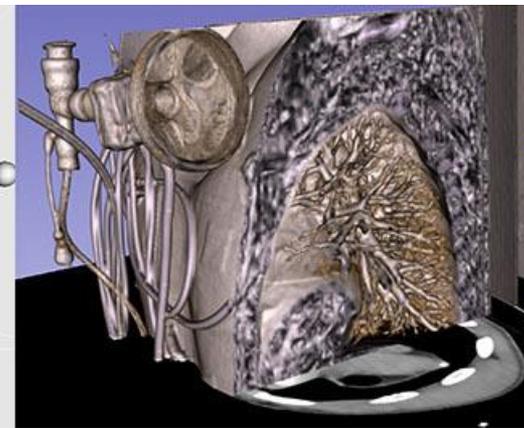
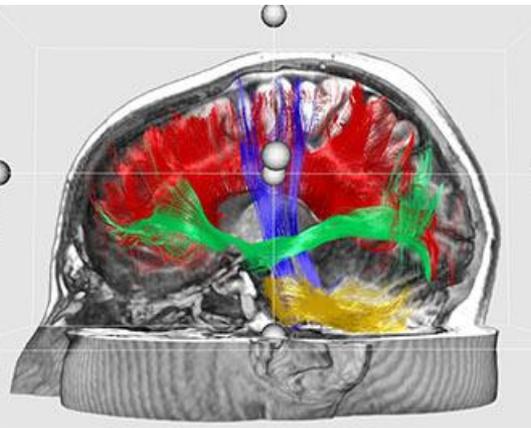
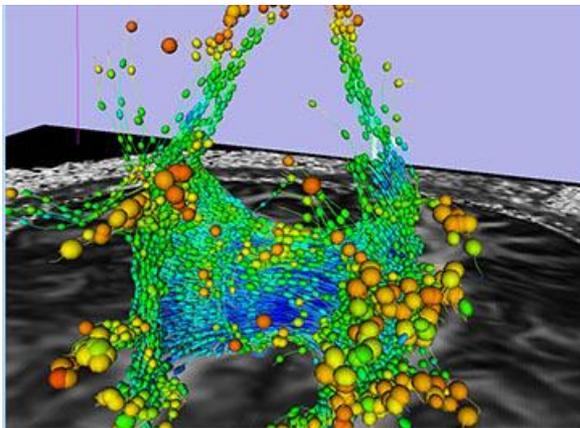
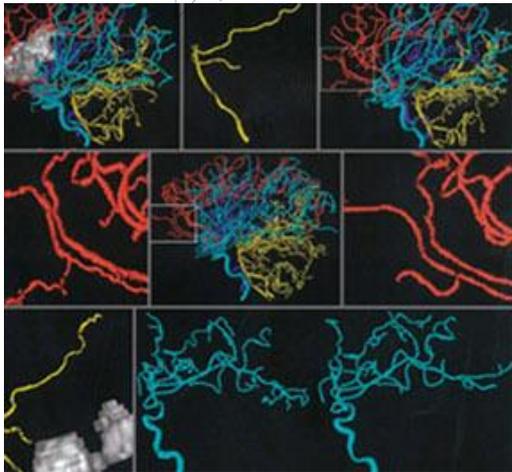


Kitware – HPC and Visualization

VTK  *ParaView*  **CMB**  **tomviz**

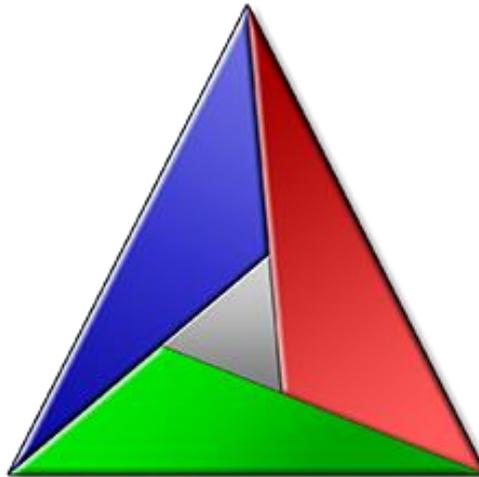


Kitware – Medical Computing



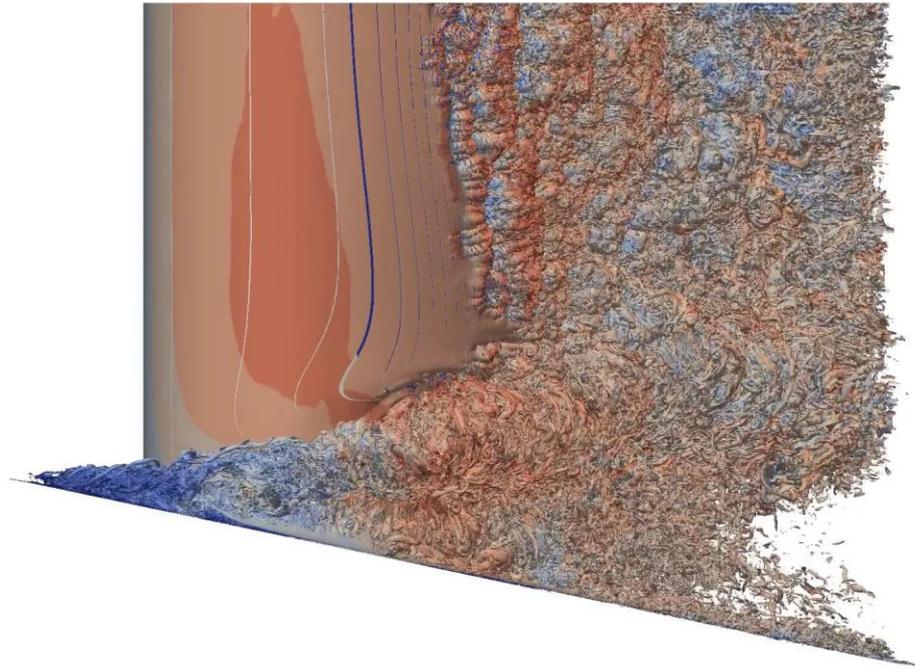
Kitware – Software Process

- cmake, ctest, cdash



To Follow Along...

- Install ParaView 5.8.0
 - <http://www.paraview.org> → Download

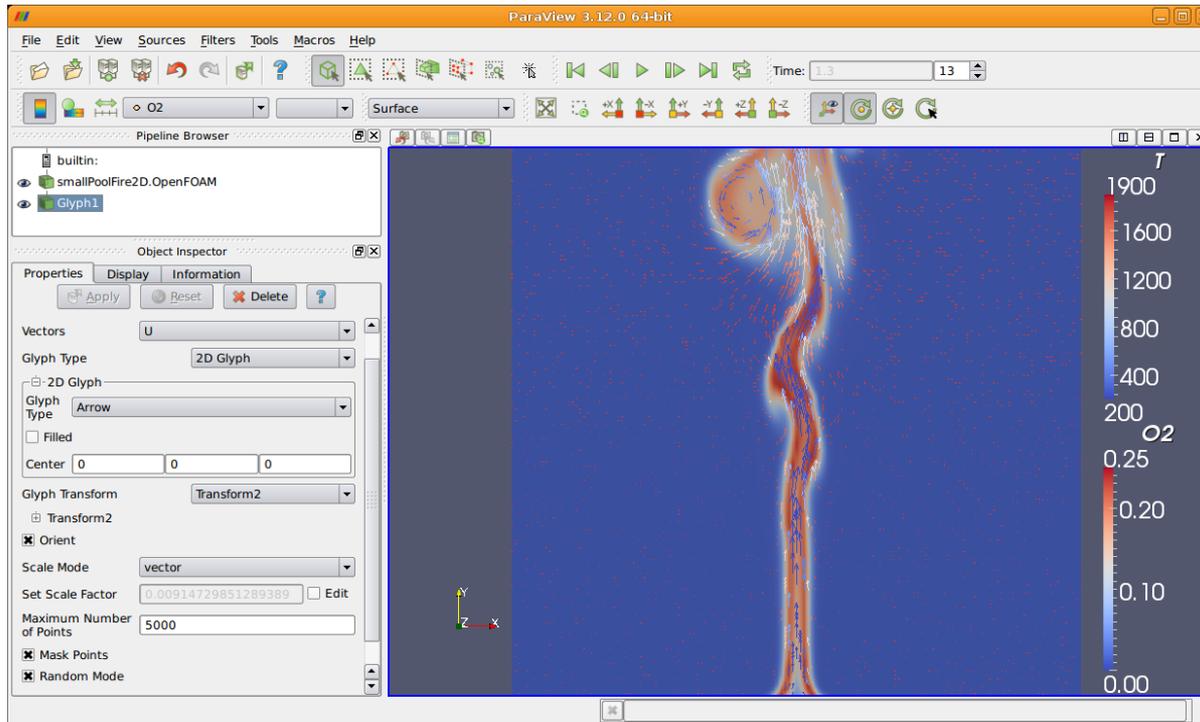


Introduction

What is ParaView?

- An open-source (BSD 3 Clause License), scalable, multi-platform visualization application.
- Support for distributed computation models to process large data sets.
- An open, flexible, and intuitive user interface.
- An extensible, **modular architecture** based on open standards.
- Commercial maintenance and support.

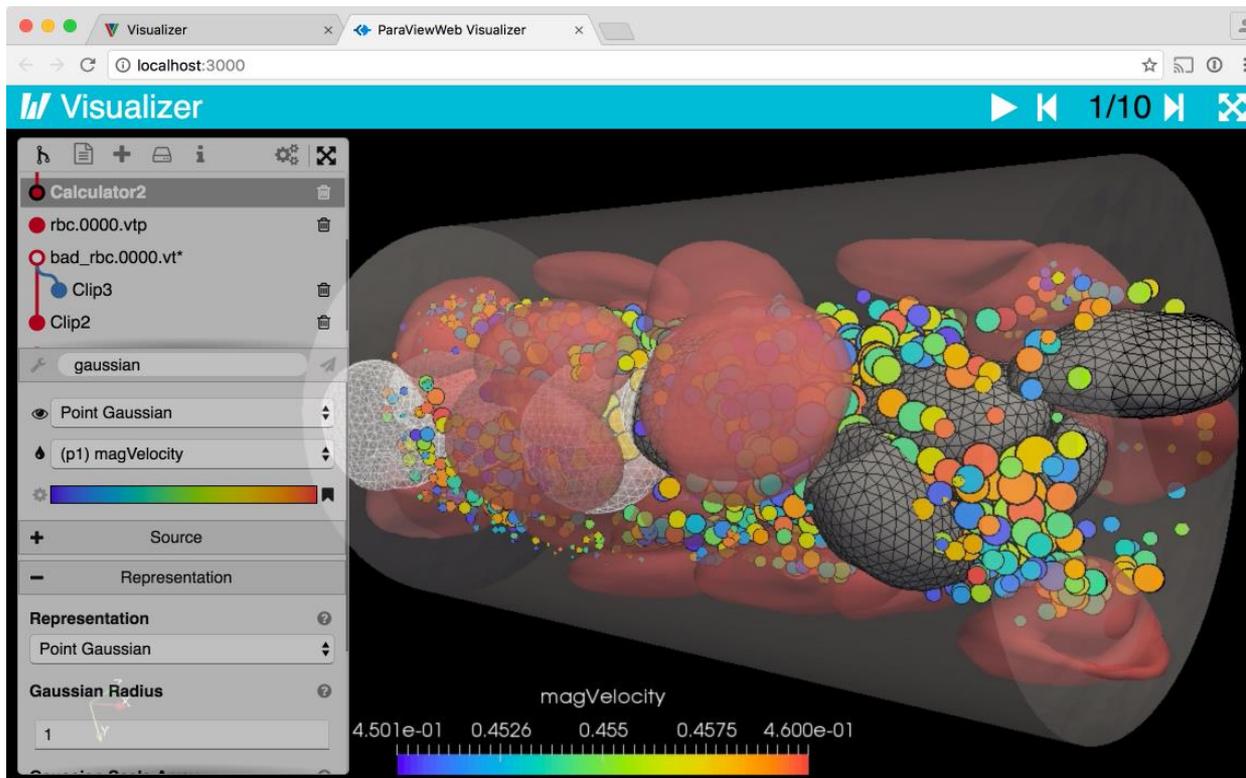
ParaView on the Desktop



ParaView on the Web

Visualizer, Glance.

<https://blog.kitware.com/vis-on-the-web/>

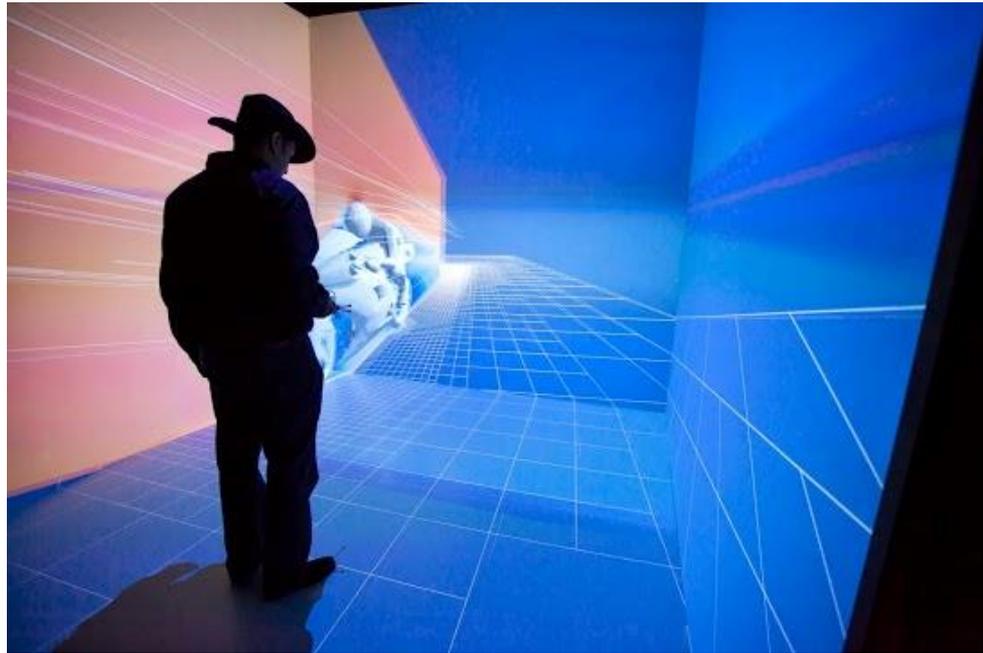


ParaView Scripting - Python



Python scripts can control ParaView, with or without the GUI, in order to create reproducible and customizable visualizations.

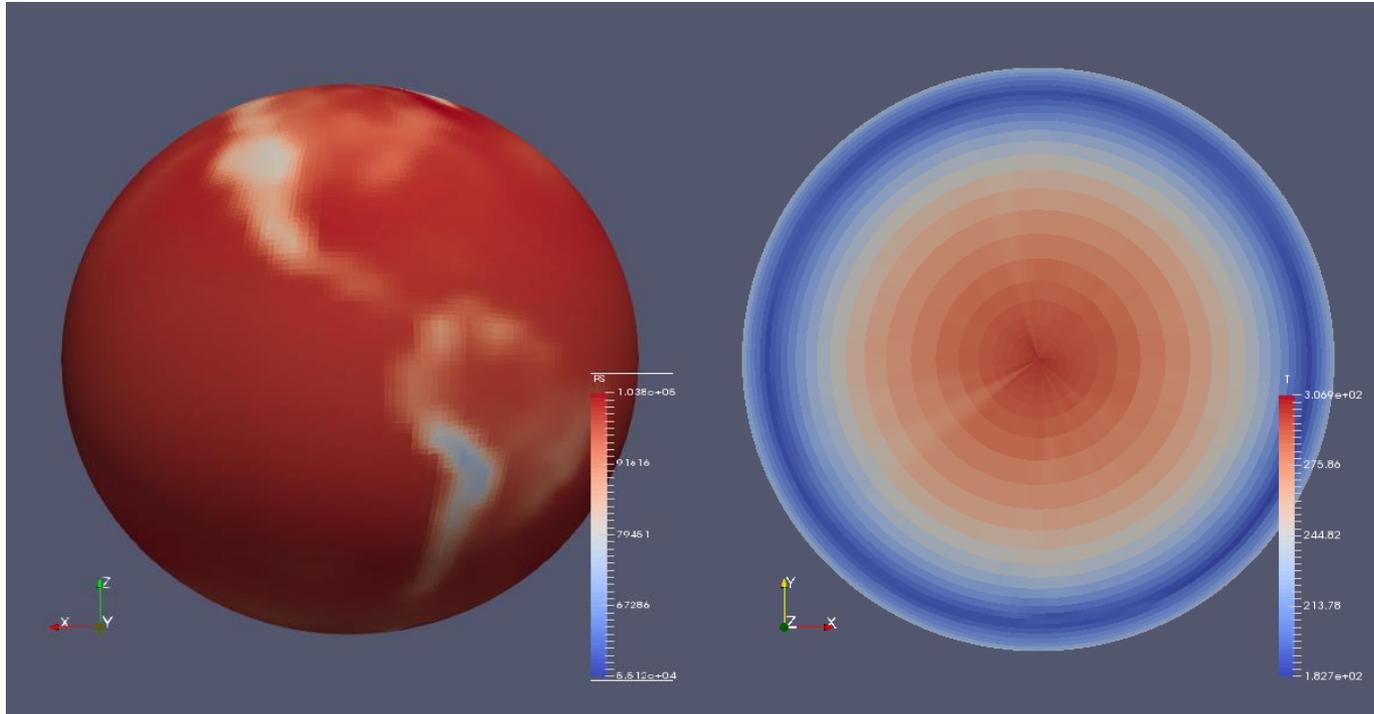
ParaView Immersive



ParaView for HPC

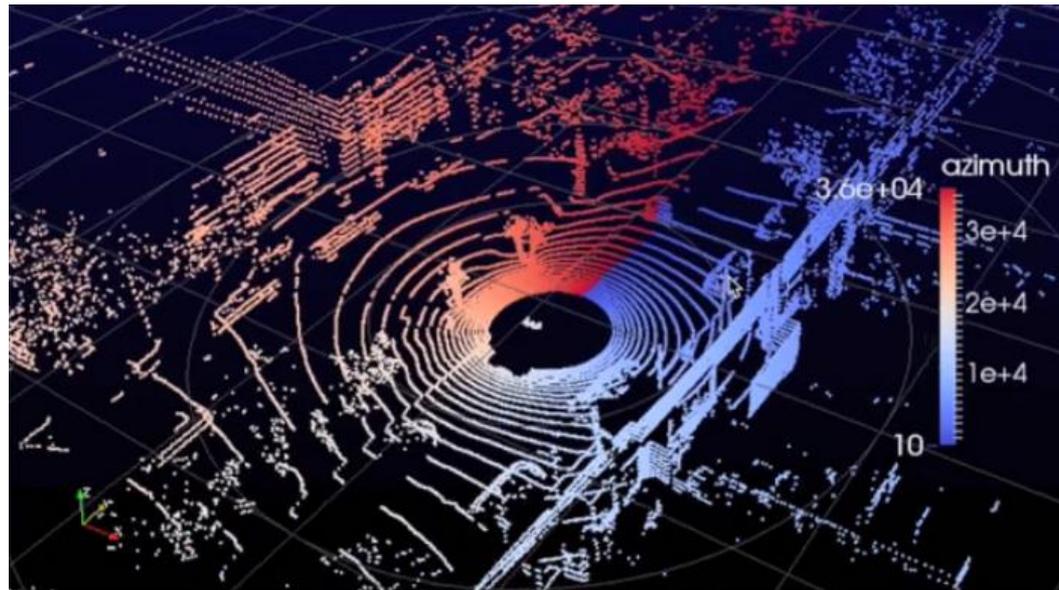
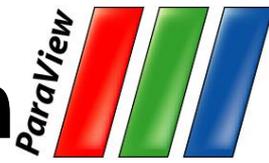


ParaView Catalyst



Community Atmosphere Model (CAM5) 2D (PS) 3D data (T), Spectral Element dynamic module.

ParaView Custom Application VeloView



Visualization of 3D LIDAR data.

Current ParaView Usage

- Used by academic, government, and commercial institutions worldwide.
- Downloaded ~135K times per year.
- HPCwire Editors' Choice 2010/2016 and HPCwire Readers' Choice 2010/2012/2015 Awards for Best Visualization Product or Technology.



Data Ranges

- Used for all ranges of data size.
- Landmarks of usage:
 - 6 billion structured cells (2005).
 - Billions of AMR cells (2008).
 - 6.33 billion unstructured cells in Catalyst (2016).
 - Scaling test over 1 Trillion cells (2010).

ParaView Development

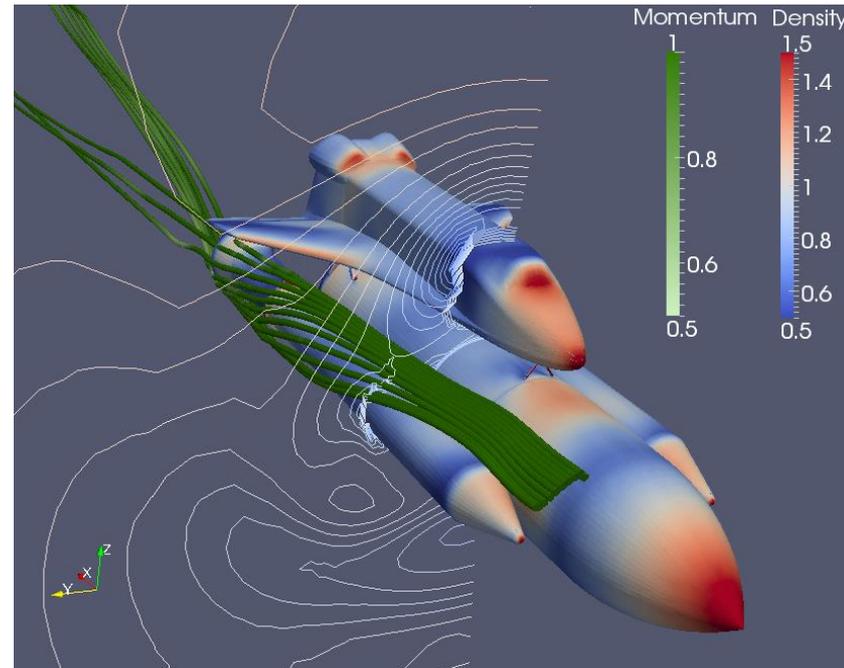
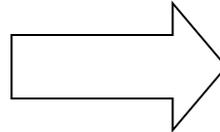
- Started in 2000 as collaborative effort between Los Alamos National Laboratories and Kitware Inc. Sandia has been a major contributor since 2005.
 - ParaView 0.6 released October 2002.
- Paraview 3.0 release in May 2007.
 - GUI rewritten to be more user friendly and powerful.
- ParaView 4.0 released in June 2013.
 - Properties panel redesign for smoother interaction.
- ParaView 5.0 released in January 2016.
 - Updated to OpenGL 3.2 features. Huge performance improvements.

Basics of Visualization

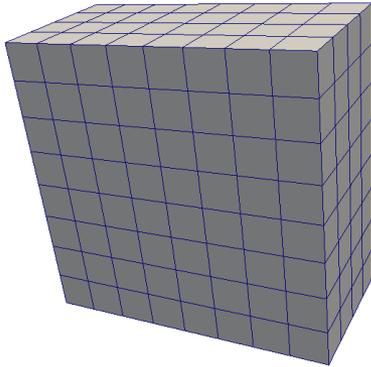
```

0265640 132304 133732 032051 037334 024721 015013 052226 001662
0265660 025537 064663 054606 043244 074076 124153 135216 126614
0265700 144210 056426 044700 042650 165230 137037 003655 006254
0265720 134453 124327 176005 027034 107614 170774 073702 067274
0265740 072451 007735 147620 061064 157435 113057 155356 114603
0265760 107204 102316 171451 046040 120223 001774 030477 046673
0266000 171317 116055 155117 134444 167210 041405 147127 050505
0266020 004137 046472 124015 134360 173550 053517 044635 021135
0266040 070176 047705 113754 175477 105532 076515 177366 056333
0266060 041023 074017 127113 003214 037026 037640 066171 123424
0266100 067701 037406 140000 165341 072410 100032 125455 056646
0266120 006716 071402 055672 132571 105645 170073 050376 072117
0266140 024451 007424 114200 077733 024434 012546 172404 102345
0266160 040223 050170 055164 164634 047154 126525 112514 032315
0266200 016041 176055 042766 025015 176314 017234 110060 014515
0266220 117156 030746 154234 125001 151144 163706 136237 164376
0266240 137055 062276 161755 115466 005322 132567 073216 002655
0266260 171466 126161 117155 065763 016177 014460 112765 055527
0266300 003767 175367 104754 036436 172172 150750 043643 145410
0266320 072074 000007 040627 070652 173011 002151 125132 140214
0266340 060115 014356 015164 067027 120206 070242 033065 131334
0266360 170601 170106 040437 127277 124446 136631 041462 116321
0266400 020243 005602 004146 121574 124651 006634 071331 102070
0266420 157504 160307 166330 074251 024520 114433 167273 030635
0266440 133614 106171 144160 010652 007365 026416 160716 100413
0266460 026630 007210 000630 121224 076033 140764 000737 003276
0266500 114060 042647 104475 110537 066716 104754 075447 112254
0266520 030374 144251 077734 015157 002513 173526 035531 150003
0266540 146207 015135 024446 130101 072457 040764 165513 156412
0266560 166410 067251 156160 106406 136770 030516 064740 022032
0266600 142166 123707 175121 071170 076357 037233 031136 015232
0266620 075074 016744 044055 102230 110063 033350 052765 172463

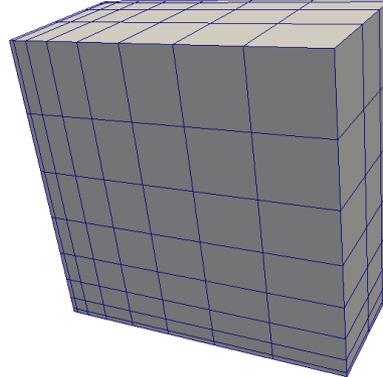
```



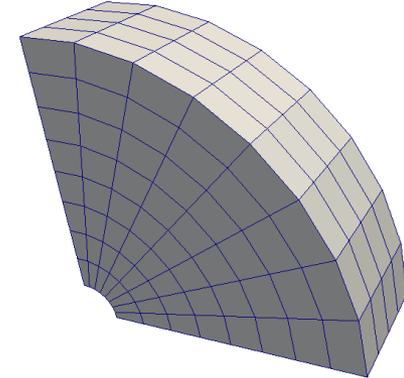
Data Types



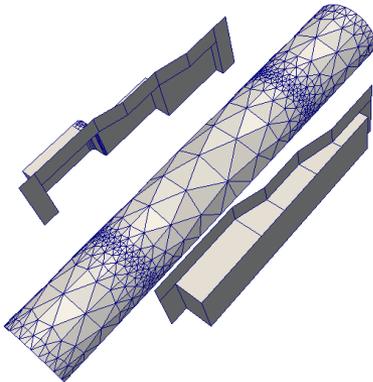
Uniform Rectilinear
(`vtkImageData`)



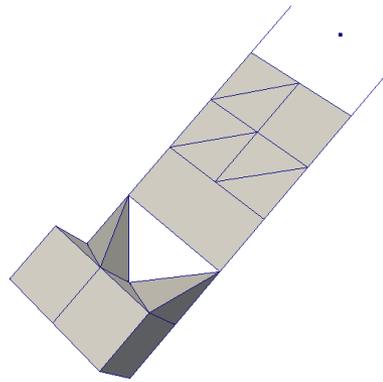
Non-Uniform Rectilinear
(`vtkRectilinearData`)



Curvilinear
(`vtkStructuredData`)



Polygonal
(`vtkPolyData`)

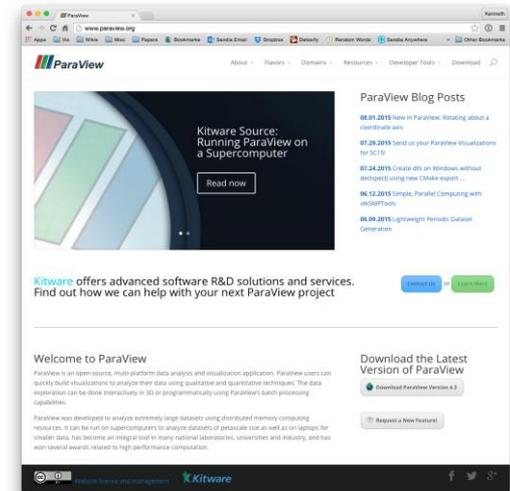


Unstructured Grid
(`vtkUnstructuredGrid`)

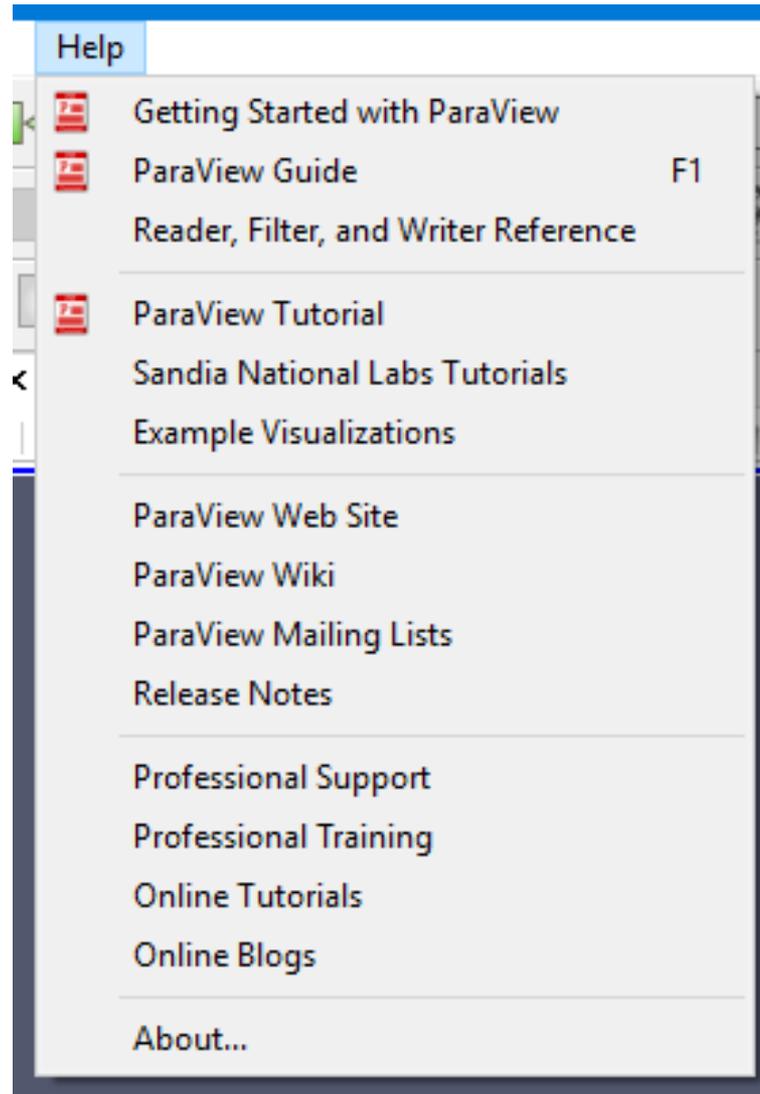
- Multi-block
- Hierarchical Adaptive Mesh Refinement (AMR)
- Hierarchical Uniform AMR
- Octree

More Information

- Help Menu
- The ParaView web page
 - www.paraview.org
- Tutorials
 - <http://www.paraview.org/tutorials/>
- *The ParaView Guide*
 - <http://www.paraview.org/paraview-guide/>
- ParaView discussion forum
 - <https://discourse.paraview.org/>



Help Menu



Basic Usage

User Interface

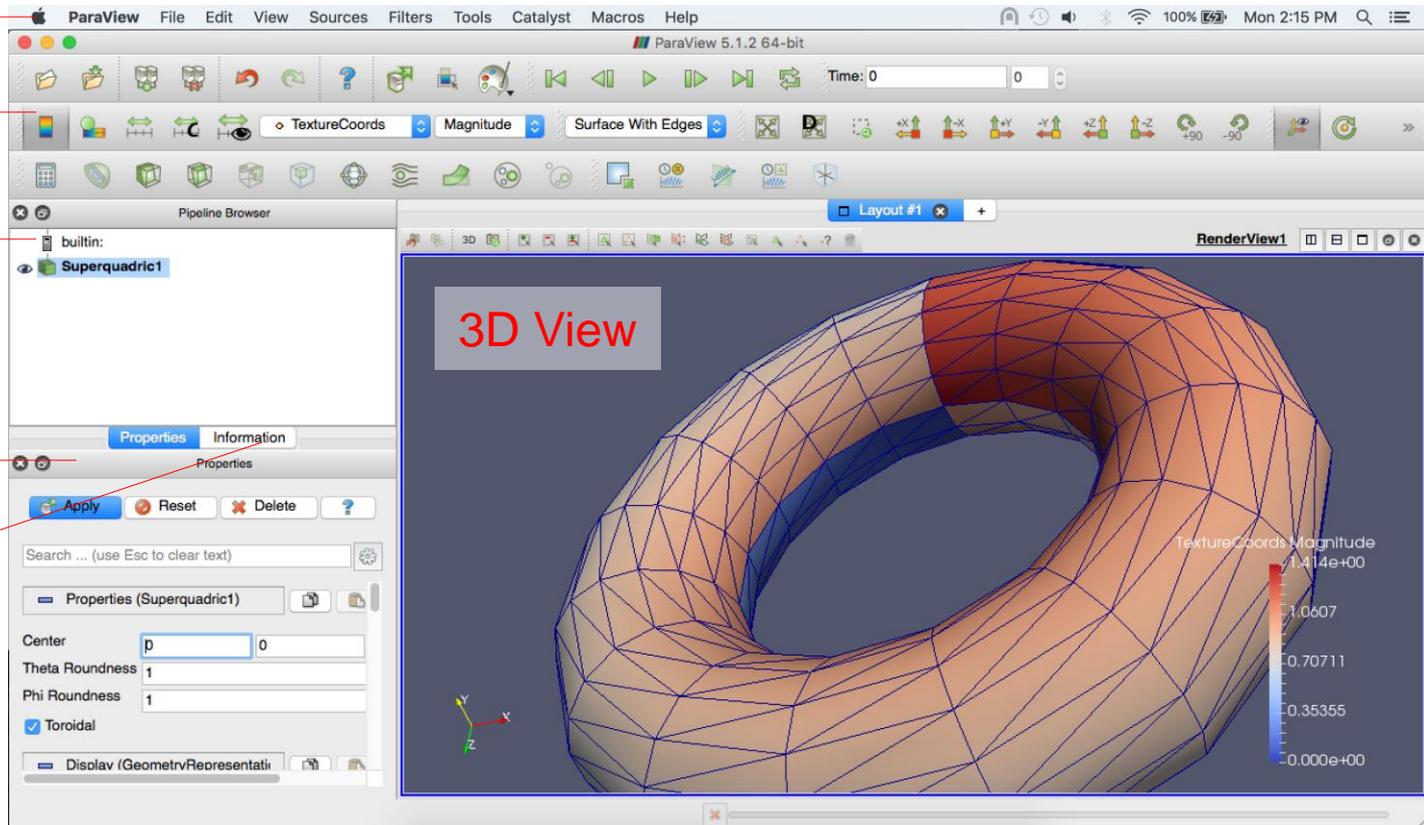
Menu Bar

Toolbars

Pipeline Browser

Properties Panel

Information Panel



Getting Back GUI Components

The screenshot shows the ParaView application window with the 'View' menu open. The 'Toolbars' submenu is also open, displaying a list of GUI components that can be toggled on or off. A mouse cursor is pointing at the 'Toolbars' menu item.

View Menu Item	Shortcut	Toolbars Submenu Item	Status
View		Active Variable Controls	✓
Sources		Camera Controls	✓
Filters		Center Axes Controls	✓
Tools		Common	✓
Catalyst		Current Time Controls	✓
Macros		DataAnalysis	✓
Help		Macros Toolbars	✓
		Main Controls	✓
		Representation Toolbar	✓
		VCR Controls	✓
		Animation View	
		Collaboration Panel	
		Color Map Editor	
		Comparative View Inspector	
		Information	✓
		Memory Inspector	
		Multi-block Inspector	
		Pipeline Browser	✓
		Properties	✓
		Selection Display Inspector	
		Statistics Inspector	
		Toggle Borders	⌘D
		Full Screen	F11

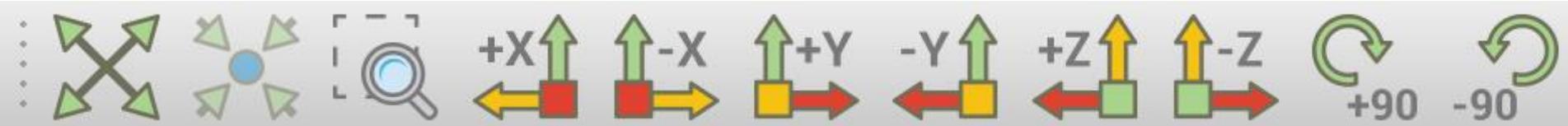
Creating a Cylinder Source

1. Go to the Sources menu and select Cylinder.
2. Click the Apply button to accept the default parameters.



Simple Camera Manipulation

- Drag left, middle, right buttons for rotate, pan, zoom.
 - Also use Shift, Ctrl, Alt modifiers.
 - Also try holding down x, y, or z.



Creating a Cylinder Source

1. Go to the Source menu and select Cylinder.
2. Click the Apply button to accept the default parameters. 
3. Increase the Resolution parameter.



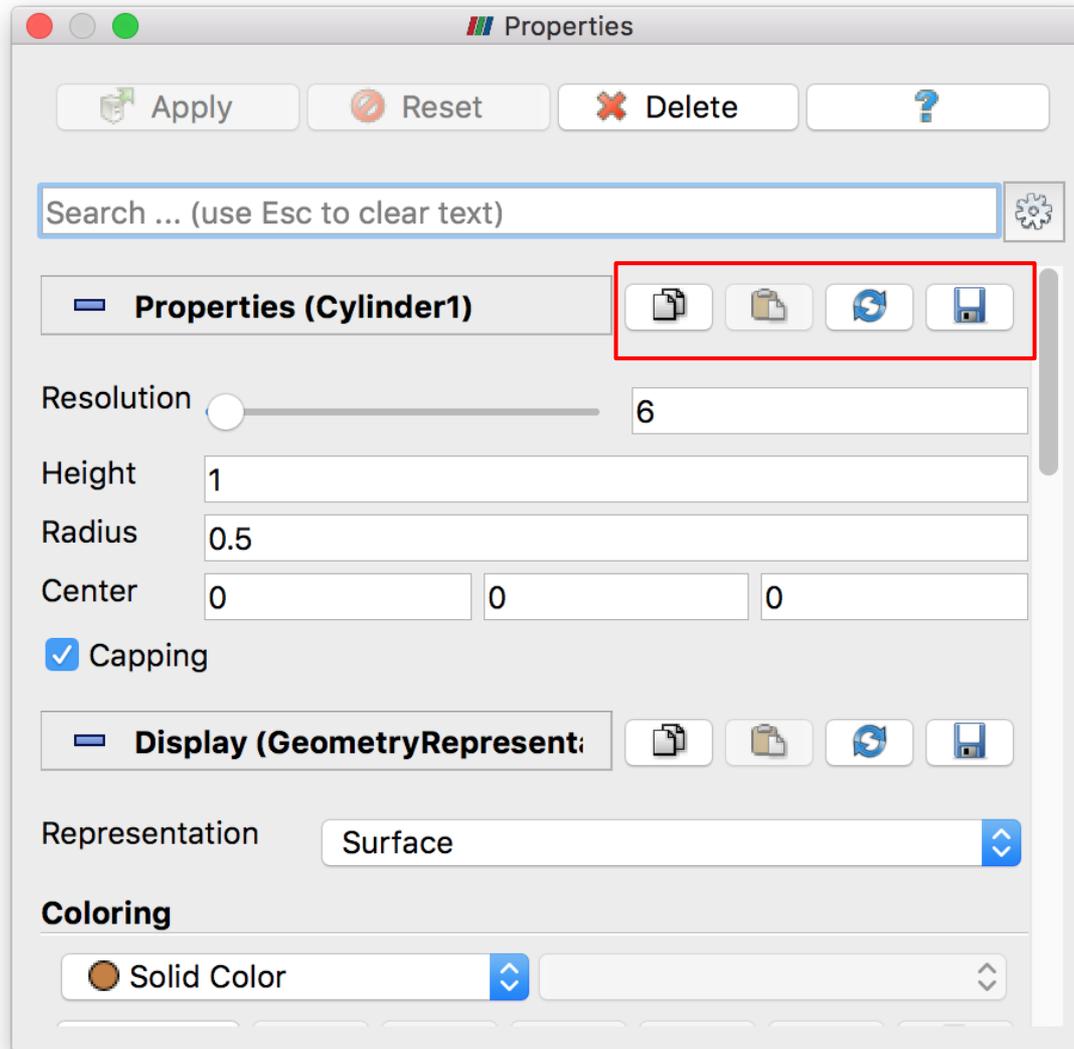
4. Click the  button again.

Pipeline Object Controls

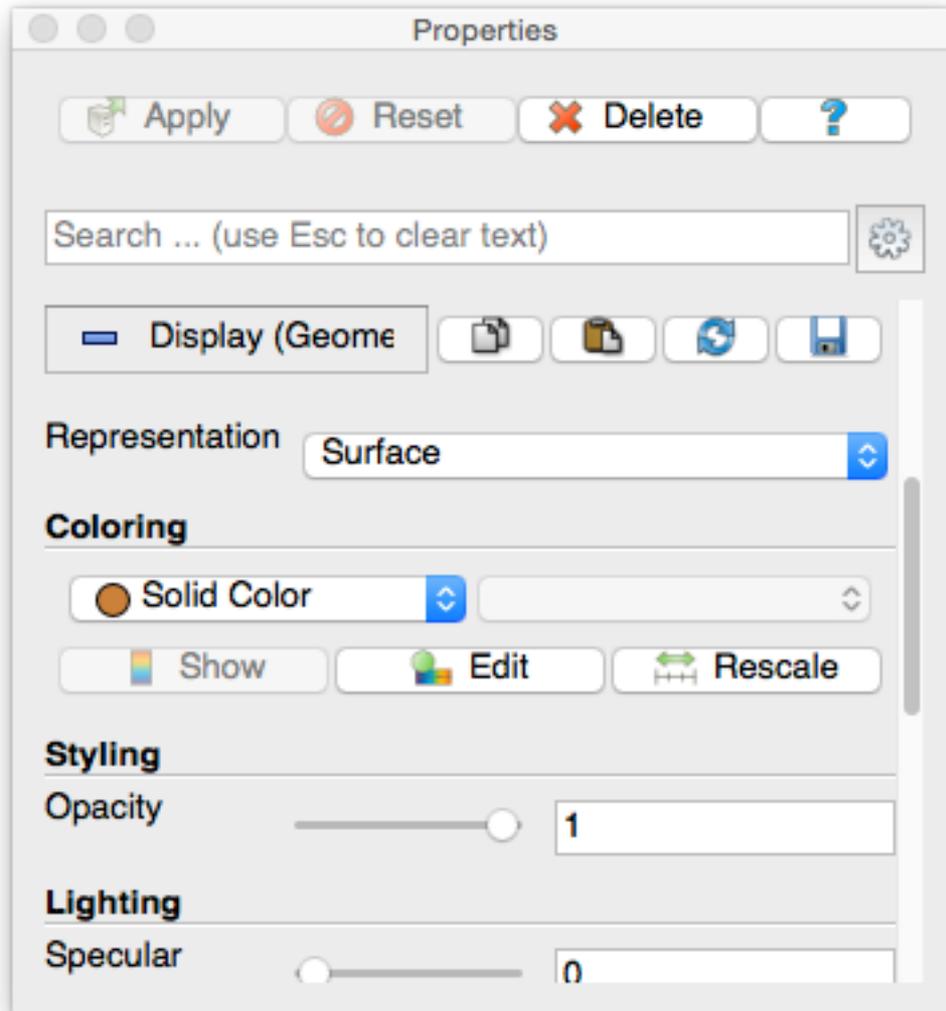


Pipeline objects {
Sources
Filters
Readers
Writers

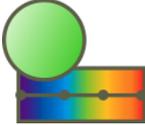
Copy/Paste/Reset/Save Properties



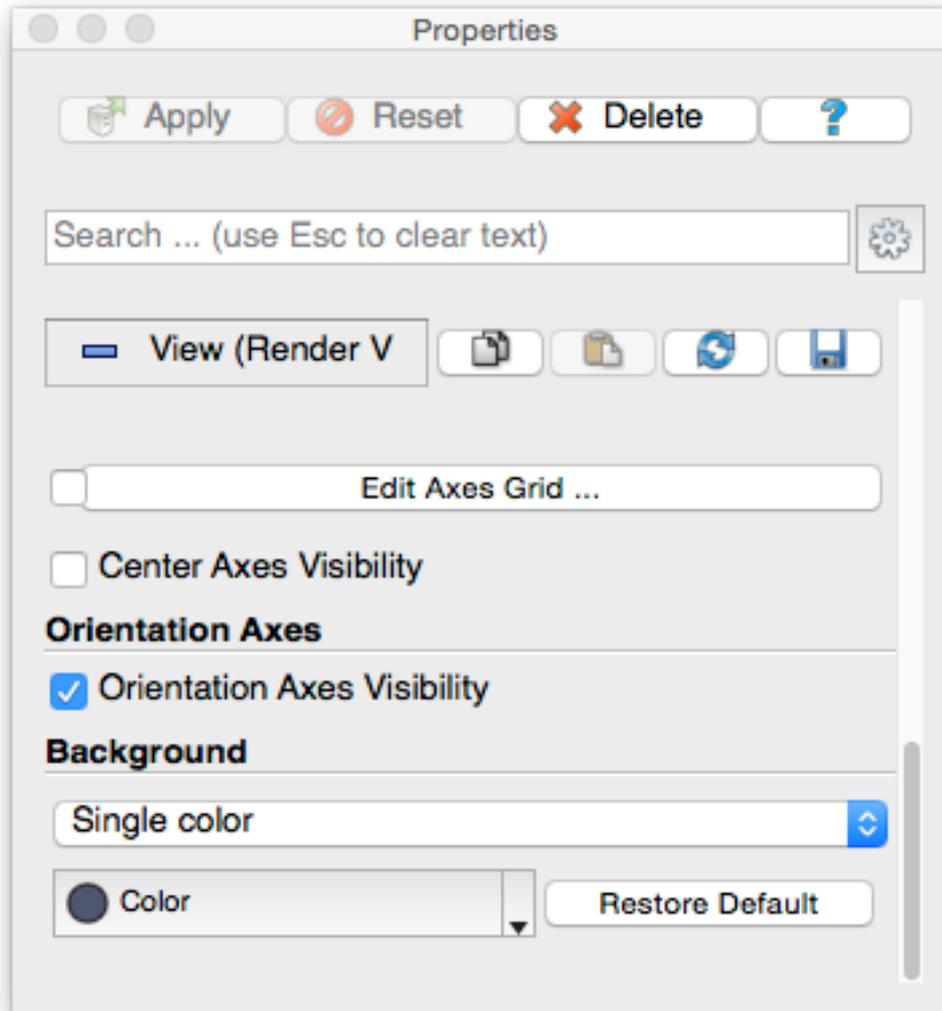
Display Properties



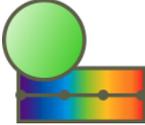
Change Display Properties

1. Scroll down to the Display group.
2. Click the  Edit button. (This button is replicated in the toolbar.)
3. Select a new color for the cylinder.

View Properties

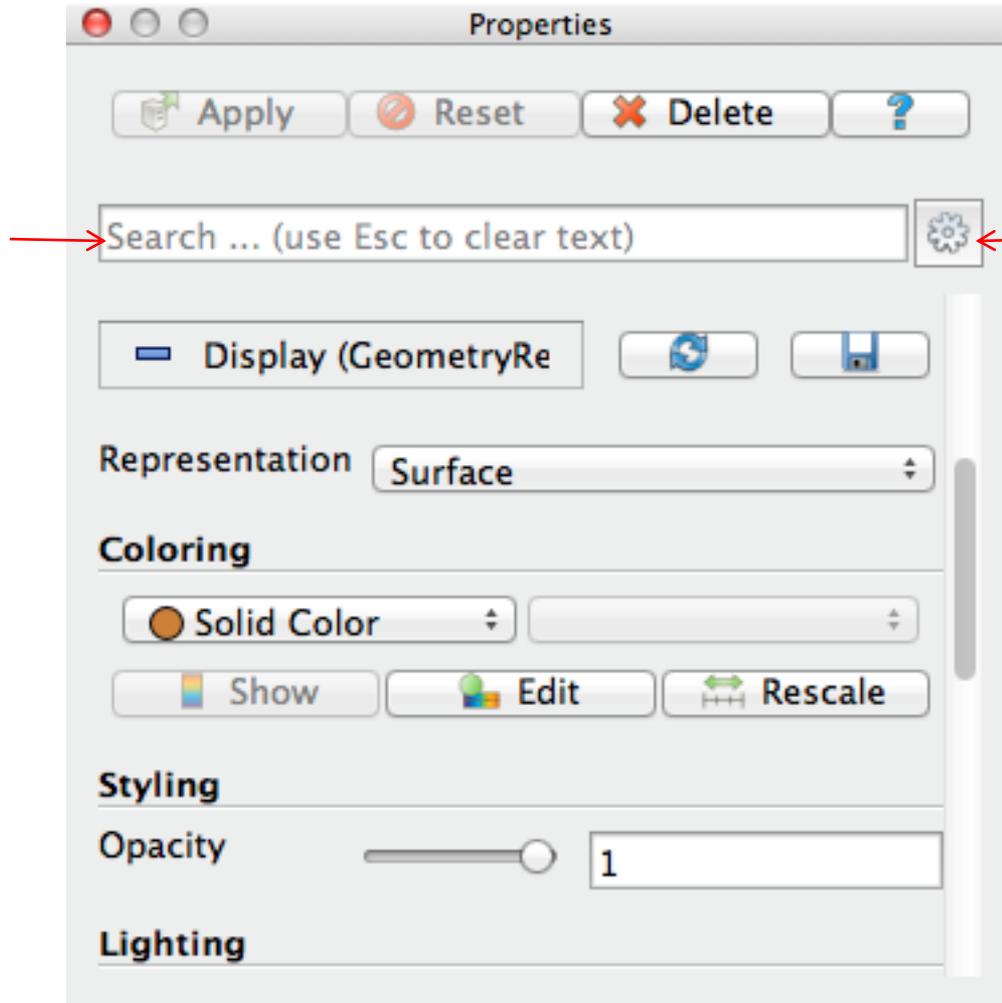


Change View Properties

1. Scroll down to the Display group.
2. Click the  Edit button. (This button is replicated in the toolbar.)
3. Select a new color for the cylinder.
4. Scroll down to the View group.
5. Turn on the Axis Grid.

Advanced Properties

Search
Properties



Toggle
Advanced
Properties

Searching Properties

1. Type “specular” in the properties search box
2. Change Specular value to 1 (makes the cylinder shiny)

Searching Properties

1. Type “specular” in the properties search box
2. Change Specular value to 1 (makes the cylinder shiny)

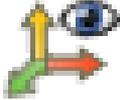
Other interesting properties:

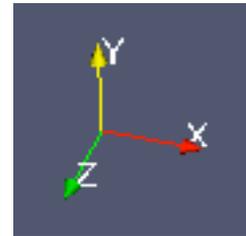
- Axes Grid
- Opacity
- Lights

Using Auto Apply

1. Click Auto Apply. 
2. Change the Resolution parameter again. 
3. Note that the visualization automatically updates without having to hit Apply.

Changing the Color Palette

1. Make sure the orientation axes are visible in the lower left corner. 



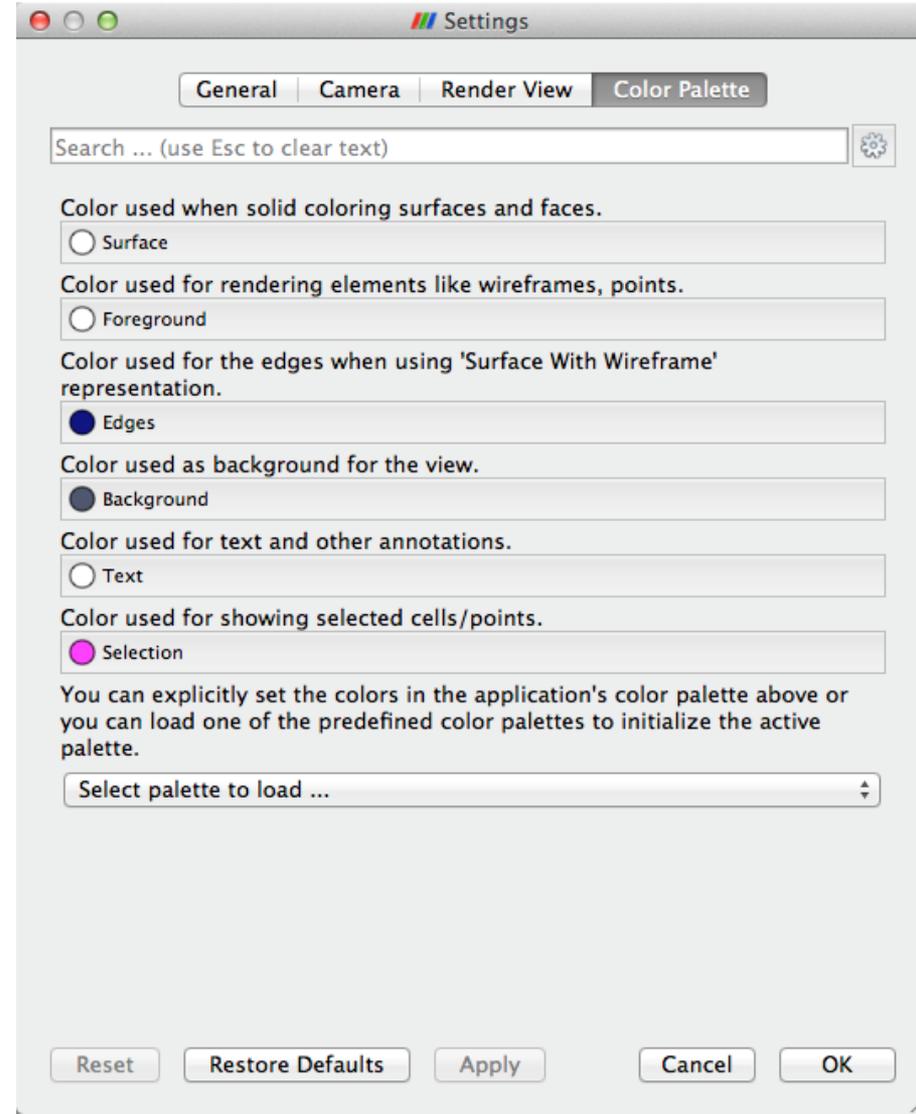
2. Click the color palette button  and change the colors.



3. Try several color palettes.

Color Palettes

 → Edit Current Palette...



Undo Redo



Undo



Redo



Camera
Undo



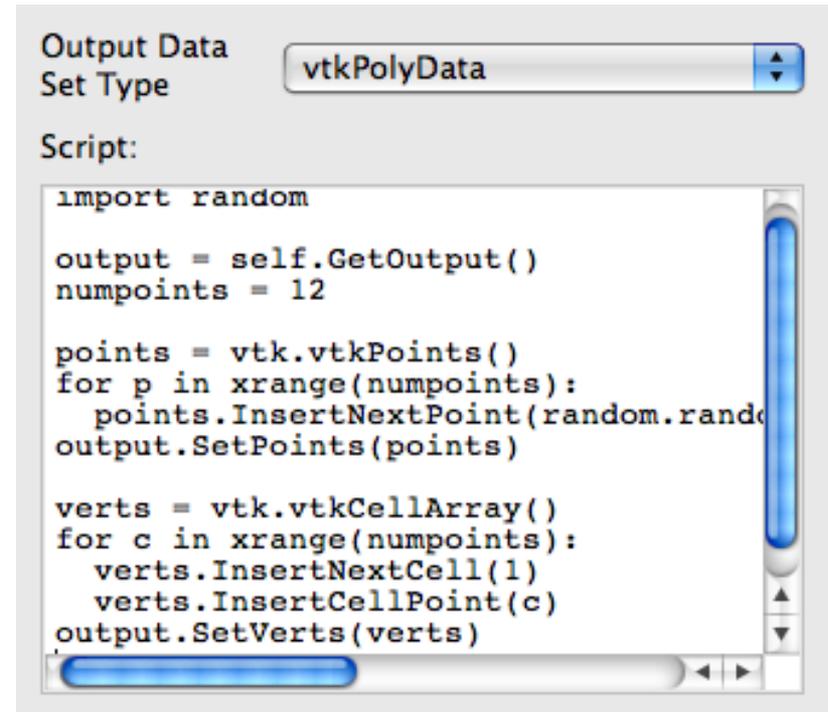
Camera
Redo

Supported Data Types

- ParaView Data (.pvd)
- VTK (.vtp, .vtu, .vti, .vts, .vtr)
- VTK Legacy (.vtk)
- VTK Multi Block (.vtm, .vtmb, .vtmg, .vthd, .vthb)
- Partitioned VTK (.pvtu, .pvti, .pvts, .pvtr)
- ADAPT (.nc, .cdf, .elev, .ncd)
- ANALYZE (.img, .hdr)
- ANSYS (.inp)
- AVS UCD (.inp)
- BOV (.bov)
- BYU (.g)
- CAM NetCDF (.nc, .ncdf)
- CCSM MTSD (.nc, .cdf, .elev, .ncd)
- CCSM STSD (.nc, .cdf, .elev, .ncd)
- CEAUcd (.ucd, .inp)
- CGNS (.cgns)
- CMAT (.cmat)
- CML (.cml)
- CTRL (.ctrl)
- Chombo (.hdf5, .h5)
- Claw (.claw)
- Comma Separated Values (.csv)
- Cosmology Files (.cosmo, .gadget2)
- Curve2D (.curve, .ultra, .ult, .u)
- DDCMD (.ddcmd)
- Digital Elevation Map (.dem)
- Dyna3D(.dyn)
- EnSight (.case, .sos)
- Enzo boundary and hierarchy
- ExodusII (.g, .e, .exe, .ex2, .ex2v., etc)
- ExtrudedVol (.exvol)
- FVCOM (MTMD, MTSD, Particle, STSD)
- Facet Polygonal Data
- Flash multiblock files
- Fluent Case Files (.cas)
- GGCM (.3df, .mer)
- GTC (.h5)
- GULP (.trg)
- Gadget (.gadget)
- Gaussian Cube File (.cube)
- JPEG Image (.jpg, .jpeg)
- LAMPPS Dump (.dump)
- LAMPPS Structure Files
- LODI (.nc, .cdf, .elev, .ncd)
- LODI Particle (.nc, .cdf, .elev, .ncd)
- LS-DYNA (.k, .lsdyna, .d3plot, d3plot)
- M3DCI (.h5)
- MFIX Unstructured Grid (.RES)
- MM5 (.mm5)
- MPAS NetCDF (.nc, .ncdf)
- Meta Image (.mhd, .mha)
- Miranda (.mir, .raw)
- Multilevel 3d Plasma (.m3d, .h5)
- NASTRAN (.nas, .f06)
- Nek5000 Files
- Nrrd Raw Image (.nrrd, .nhrd)
- OpenFOAM Files (.foam)
- PATRAN (.neu)
- PFLOTRAN (.h5)
- PLOT2D (.p2d)
- PLOT3D (.xyz, .q, .x, .vp3d)
- PLY Polygonal File Format
- PNG Image Files
- POP Ocean Files
- ParaDIS Files
- Phasta Files (.pht)
- Pixie Files (.h5)
- ProSTAR (.cel, .vrt)
- Protein Data Bank (.pdb, .ent, .pdb)
- Raw Image Files
- Raw NRRD image files (.nrrd)
- SAMRAI (.samrai)
- SAR (.SAR, .sar)
- SAS (.sasgeom, .sas, .sasdata)
- SESAME Tables
- SLAC netCDF mesh and mode data
- SLAC netCDF particle data
- Silo (.silo, .pdb)
- Spherical (.spherical, .sv)
- SpyPlot CTH
- SpyPlot (.case)
- SpyPlot History (.hscth)
- Stereo Lithography (.stl)
- TFT Files
- TIFF Image Files
- Tsurf Files
- Tecplot ASCII (.tec, .tp)
- Tecplot Binary (.plt)
- Tetrad (.hdf5, .h5)
- UNIC (.h5)
- VASP CHGCA (.CHG)
- VASP OUT (.OUT)
- VASP POSTCAR (.POS)
- VPIC (.vpc)
- VRML (.vrl)
- Velodyne (.vld, .rst)
- VizSchema (.h5, .vsh5)
- Wavefront Polygonal Data (.obj)
- WindBlade (.wind)
- XDMF and hdf5 (.xmf, .xdmf)
- XMOl Molecule

Custom Data Import: Prototype with Python

- A “programmable source” lets you program data readers right in the GUI.
- Uses wrappings for the basic VTK classes.
- Good for prototyping readers.



The screenshot shows the ParaView GUI's 'Programmable Source' panel. The 'Output Data Set Type' is set to 'vtkPolyData'. The 'Script' field contains the following Python code:

```
import random

output = self.GetOutput()
numpoints = 12

points = vtk.vtkPoints()
for p in xrange(numpoints):
    points.InsertNextPoint(random.random())
output.SetPoints(points)

verts = vtk.vtkCellArray()
for c in xrange(numpoints):
    verts.InsertNextCell(1)
    verts.InsertCellPoint(c)
output.SetVerts(verts)
```

<https://www.vtk.org/doc/nightly/html/>

Custom Data Import: Plugin Containing a Reader

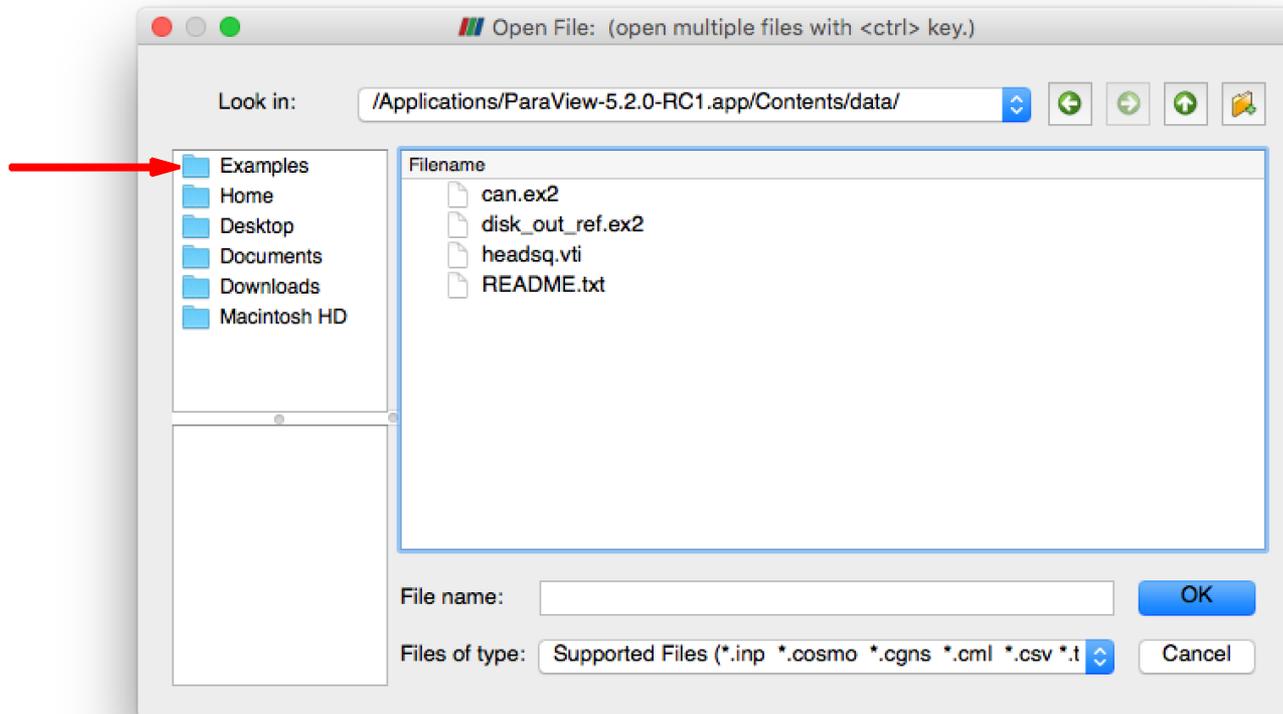
- Plugins: shared object libraries that can be dynamically loaded into ParaView.
- C++ code and XML description of the interface.
- Any VTK reader object can be added.

Custom Data Import: Python Reader/Filter Plugin

- Python code and python decorators
description of the interface (similar with
the XML description).
- [PythonAlgorithmExamples.py](#)

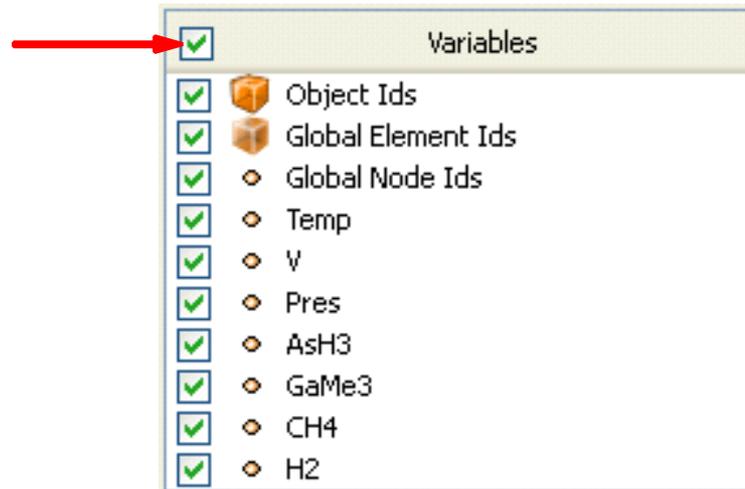
Load disk_out_ref.ex2

1. Open the file `disk_out_ref.ex2` from the examples directory.



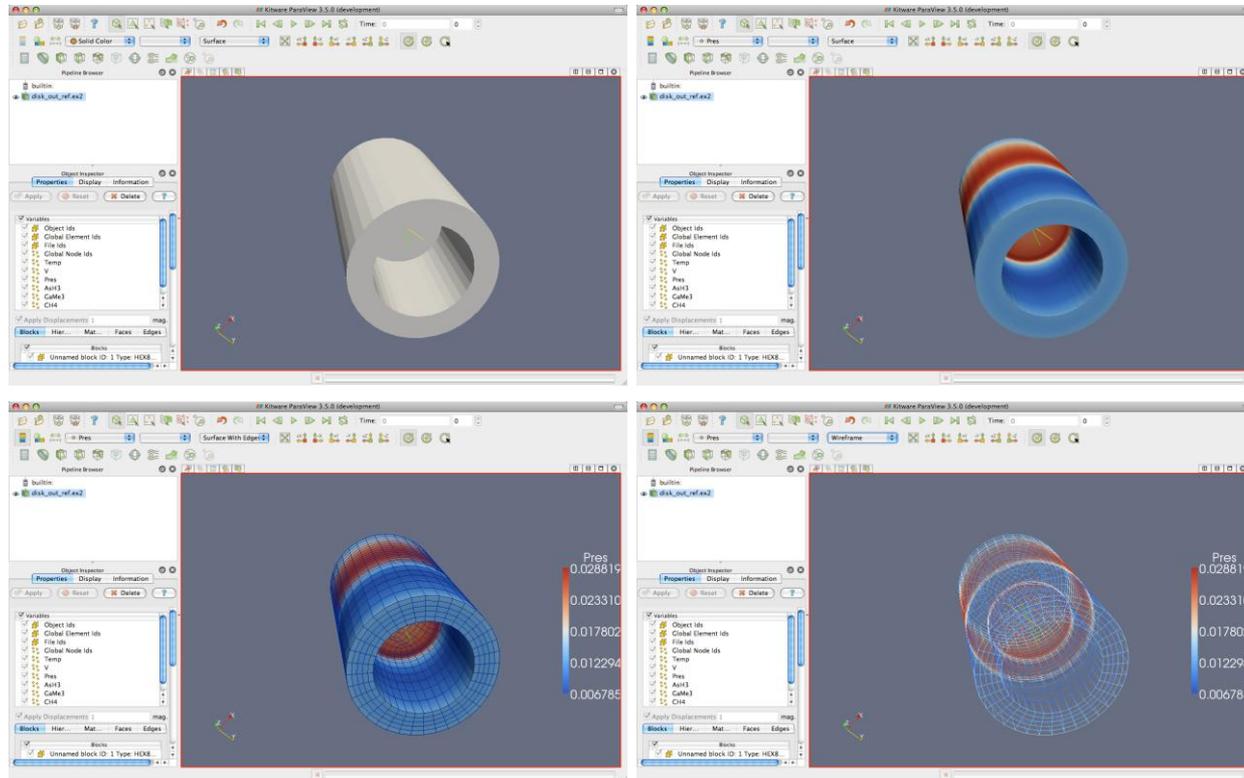
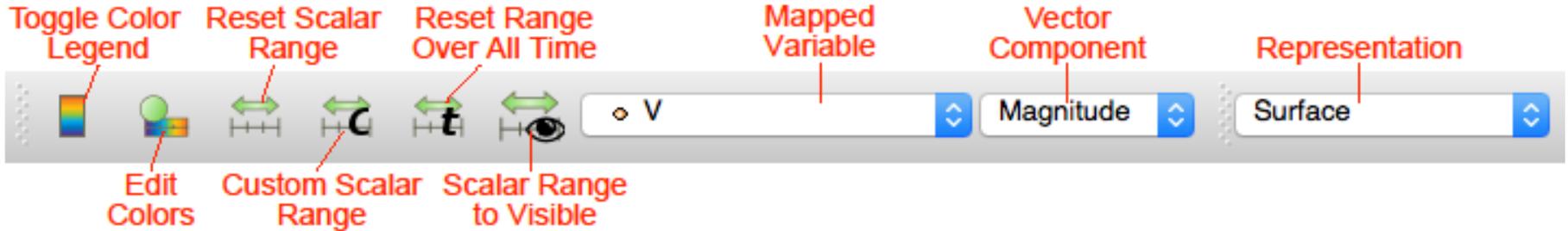
Load disk_out_ref.ex2

1. Open the file disk_out_ref.ex2 from the examples directory.
2. Load all data variables.

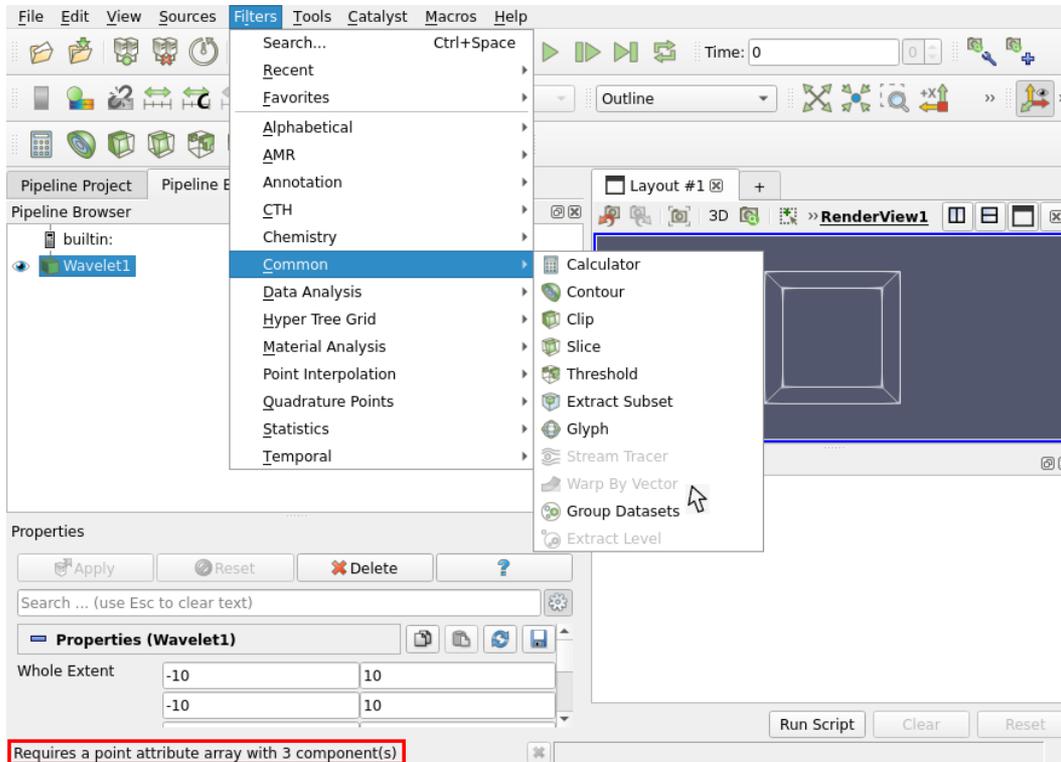


3. Click 

Data Representation



Filters Menu



~200 filters

Status bar:

- Short description
- Reason why is grayed

Common Filters



Calculator



Contour



Clip



Slice



Threshold



Extract Subset



Glyph



Stream Tracer



Warp (vector)

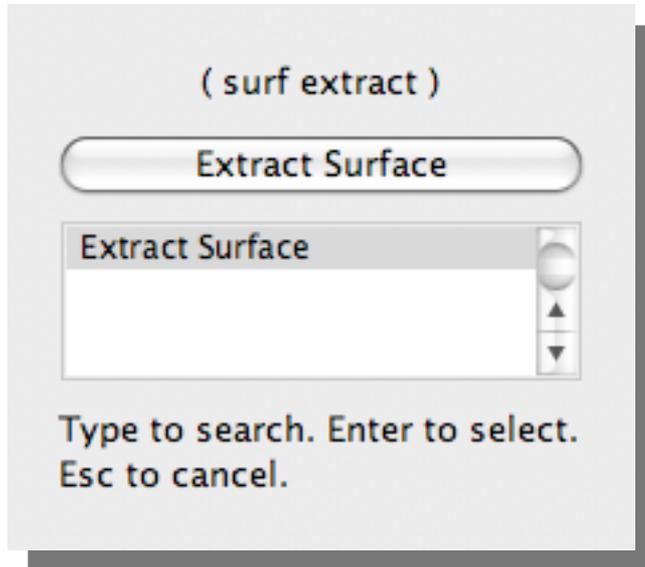


Group Datasets



Extract Level

Quick Launch



- Used for searching for filters by name
- Keyboard shortcut
 - Ctrl-space for Windows & Linux
 - Alt-space for Mac

Apply Contour

1. Select disk_out_ref.ex2 in the pipeline browser.
2. Press the contour filter. 

Specify the data you
apply the filter on

Apply Contour

3. Change parameters to create an isosurface at Temp = 400K.

The screenshot shows the 'Properties' window for a 'Contour1' object. The 'Contour' section has 'Contour By' set to 'AsH3'. The 'Isosurfaces' section shows a 'Value Range' of [0.0804768, 0.184839] and a list of values with '0.132658146' selected. Red arrows point to the 'Contour By' dropdown and the value '0.132658146' with labels 'Change to Temp' and 'Change to 400' respectively.

Change to Temp

Change to 400

Apply Contour

1. Select disk_out_ref.ex2 in the pipeline browser.
2. Select the contour filter. 
3. Change parameters to create an isosurface at Temp = 400K.
4. 

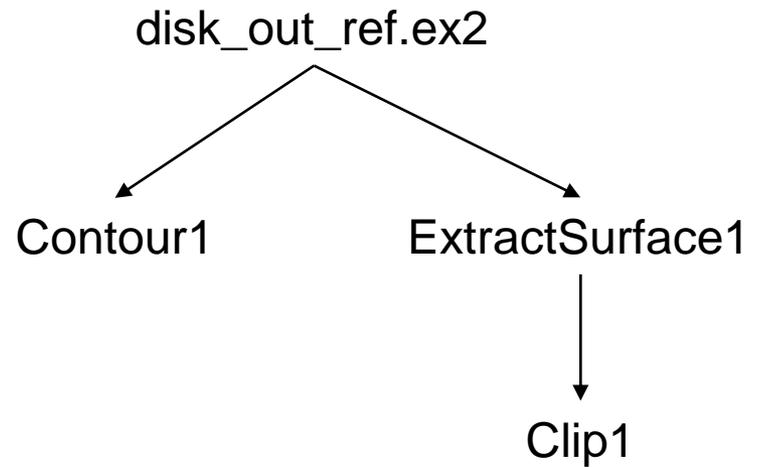
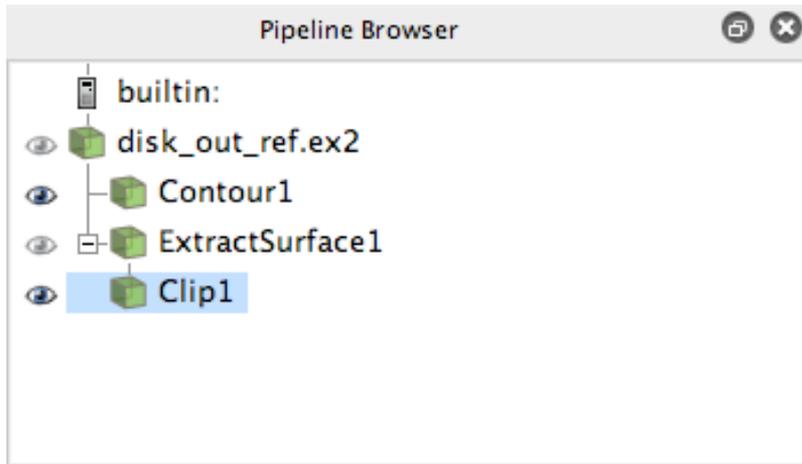
Apply ExtractSurface

1. Select `disk_out_ref.ex2` in the pipeline browser.
2. From the quick launch, select Extract Surface.
3. A blue rectangular button with rounded corners. On the left side, there is a small icon of a document with a green checkmark. To the right of the icon, the word "Apply" is written in a black, sans-serif font.

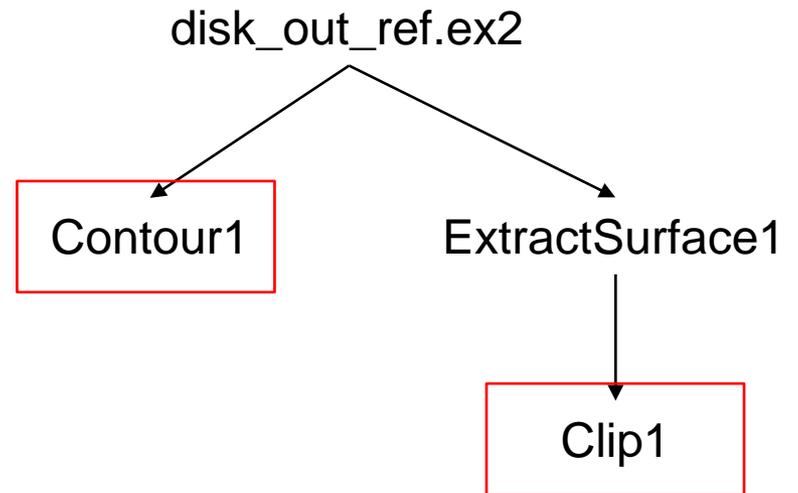
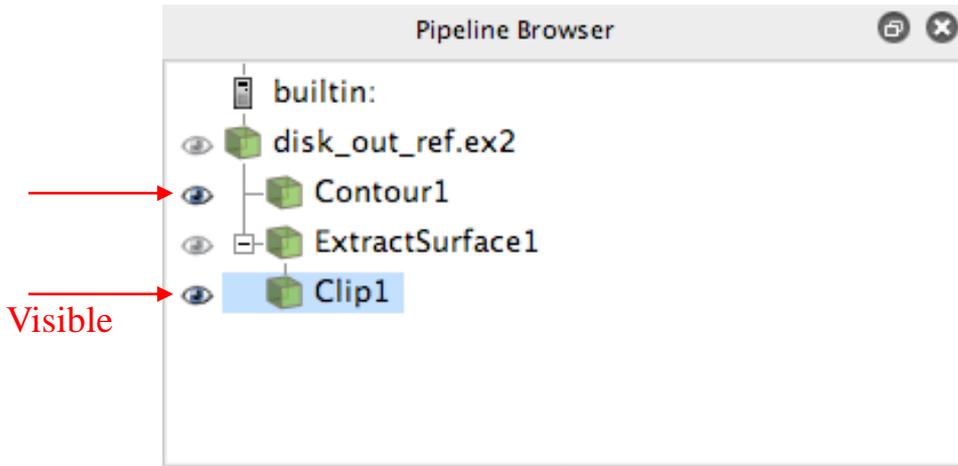
Apply ExtractSurface, Clip

1. Select `disk_out_ref.ex2` in the pipeline browser.
2. From the quick launch, select Extract Surface.
3.  Apply
4. **Select ...** Create a clip filter. 
5. Uncheck Show Plane. Show Plane
6.  Apply

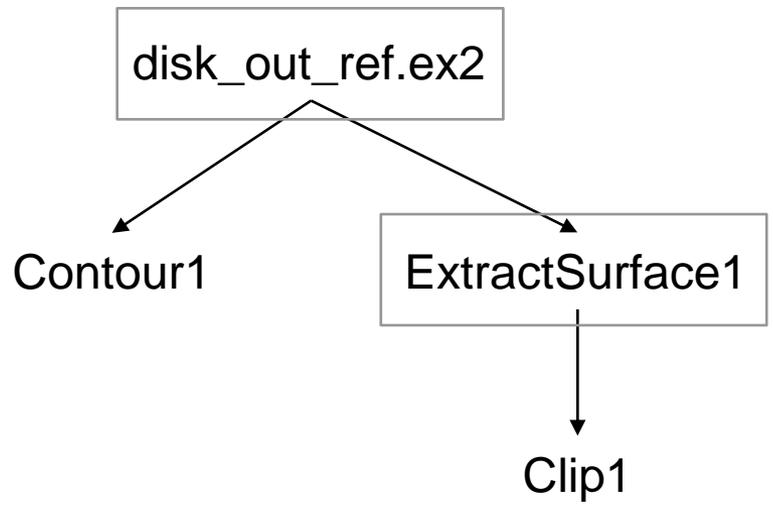
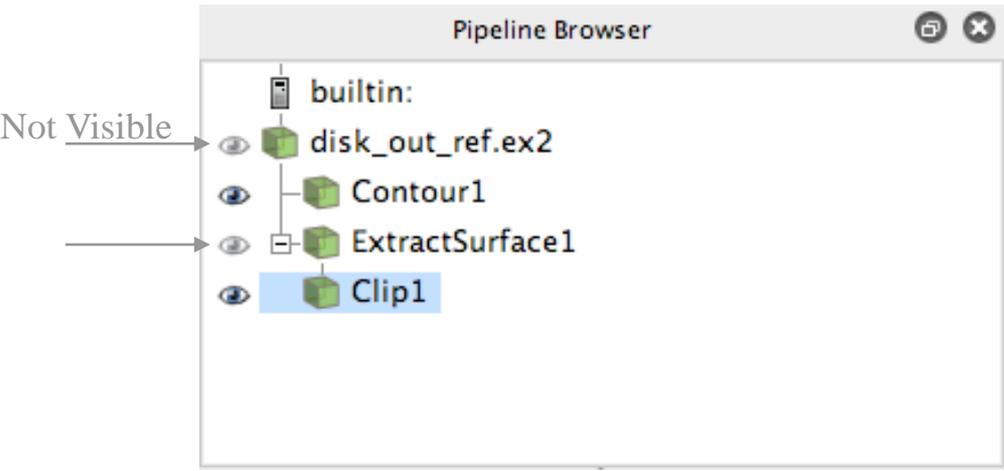
Pipeline Browser Structure



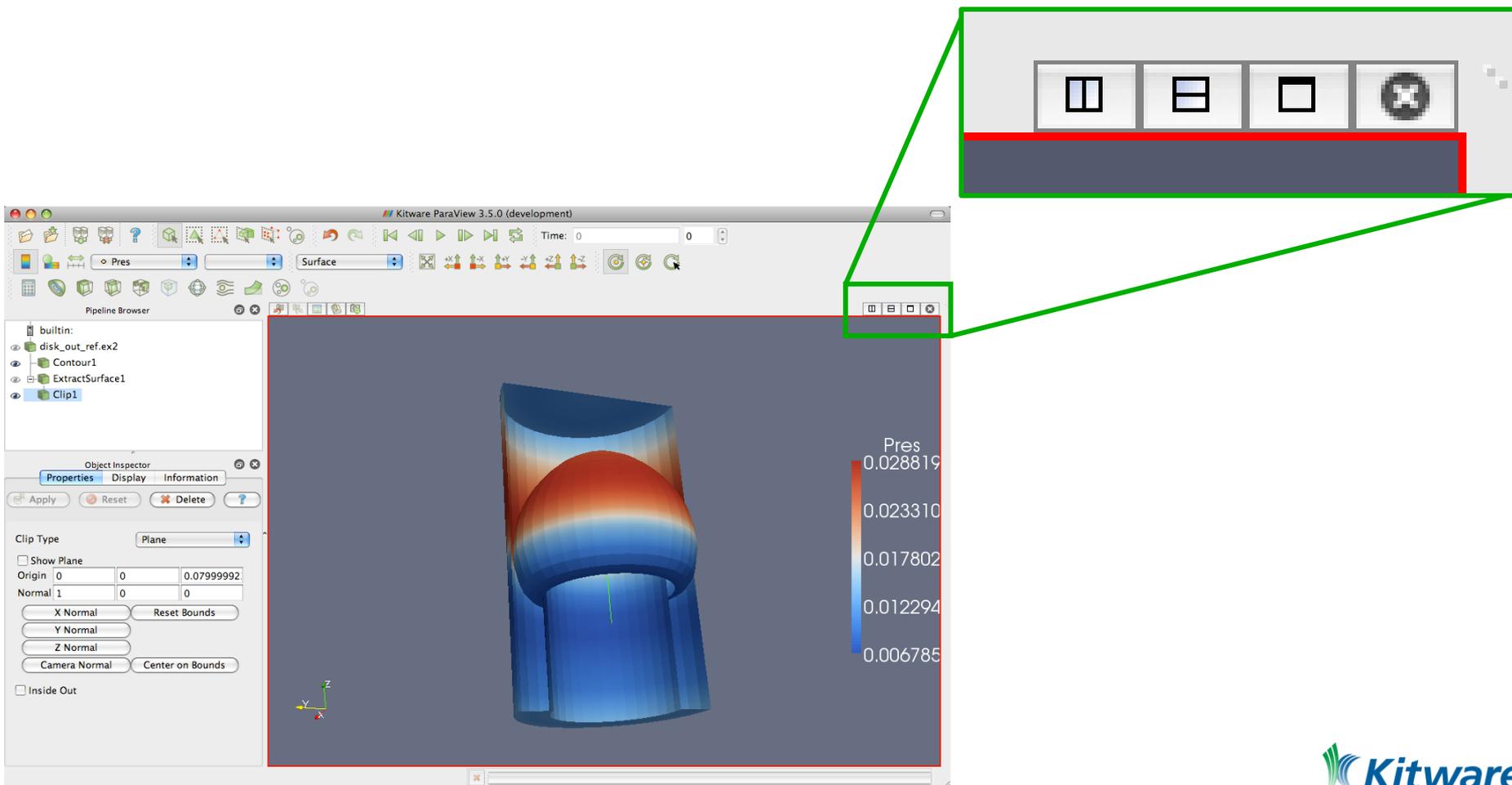
Pipeline Browser Structure



Pipeline Browser Structure



Multiview



Multiview

1. Select disk_out_ref.ex2 in the pipeline browser.
2. Add Clip filter. 
3. Uncheck Show Plane.  Show Plane
4.  Apply
5. Color surface by Pres.
6. Hide Clip2 

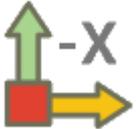
Multiview

6. Split the view horizontally. 
7. Make Clip2 visible. 
8. Color surface by Temp.

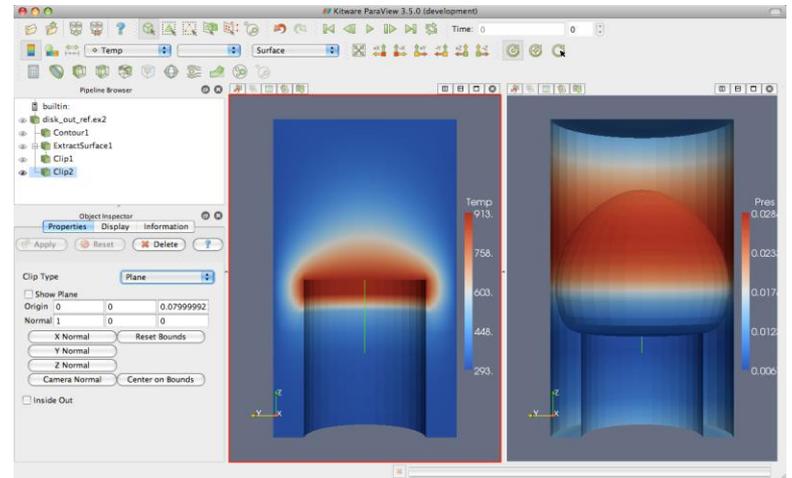
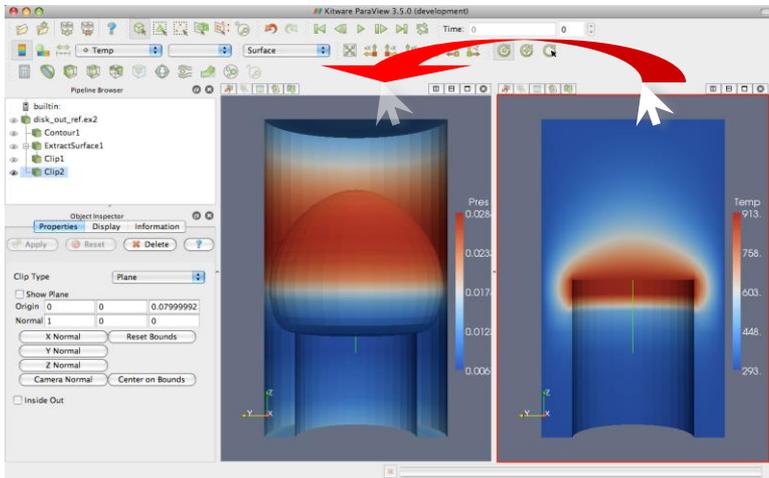
Multiview

6. Split the view horizontally. 
7. Make Clip1 visible. 
8. Color surface by Temp.
9. Right-click view, Link Camera...
10. Click other view.

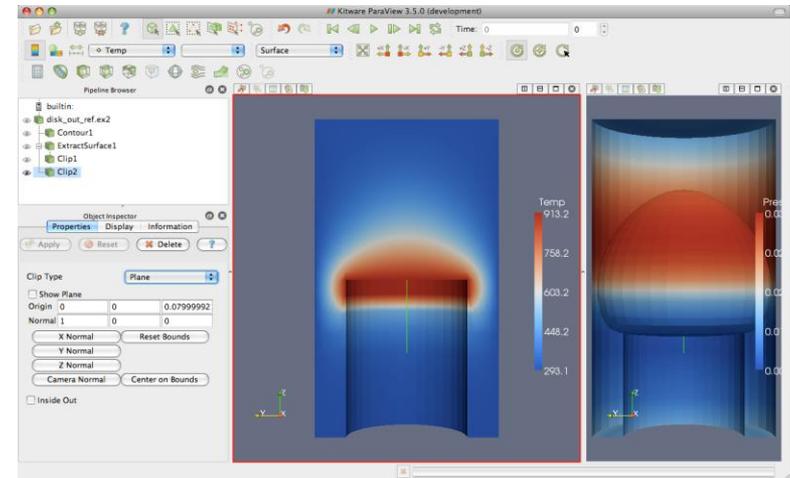
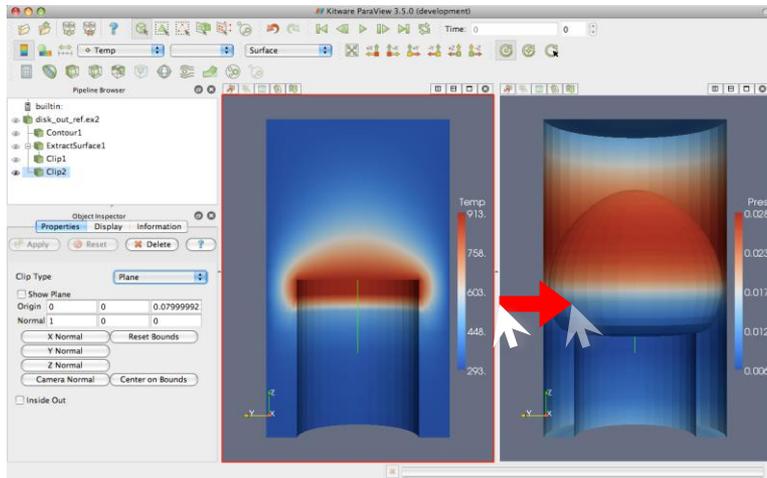
Multiview

6. Split the view horizontally. 
7. Make Clip1 visible. 
8. Color surface by Temp.
9. Right-click view, Link Camera...
10. Click other view.
11. Click  -x and zoom in a bit.

Modifying Views

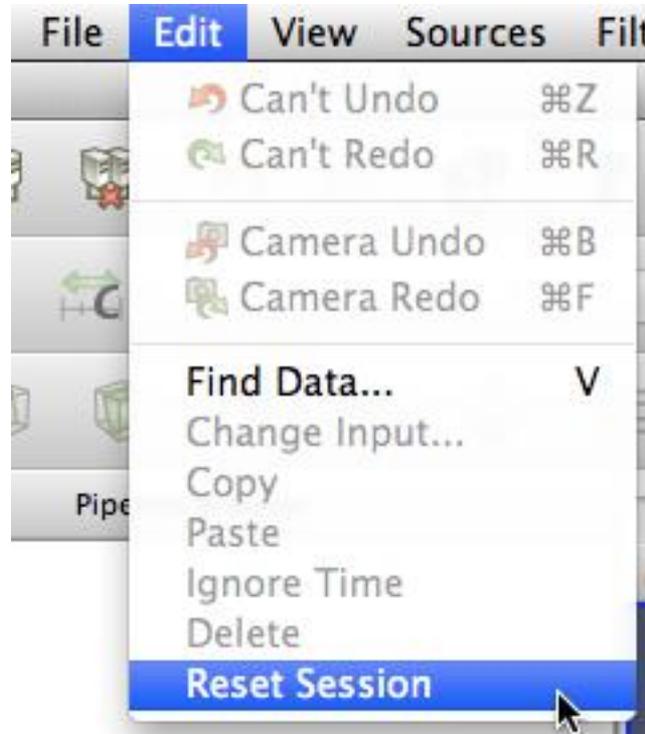


Modifying Views



Reset ParaView

Edit → Reset Session



Streamlines

1. Open disk_out_ref.ex2. Load all variables. 
2. Add Stream Tracer. 
3. Change Seed Type to Point Source.
4. Uncheck Show Sphere. Show Sphere
5. 

Streamlines

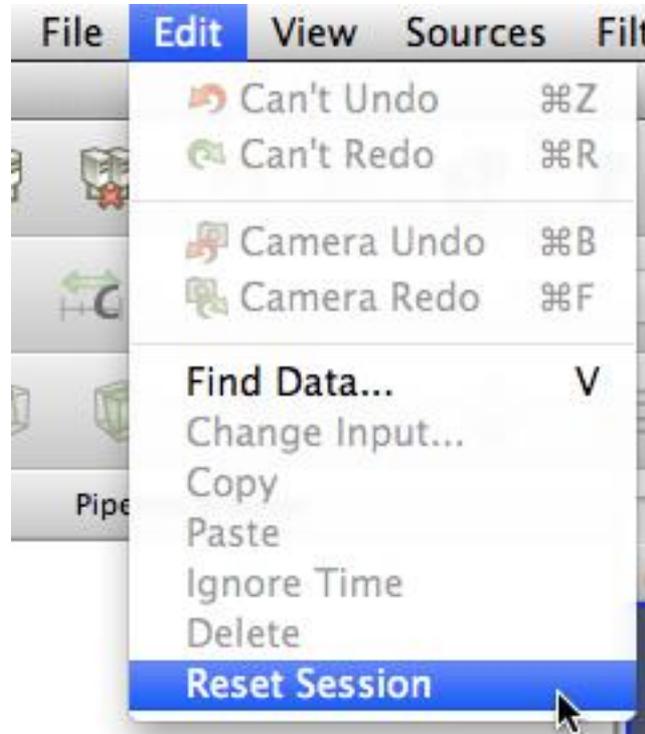
1. Open disk_out_ref.ex2. Load all variables. 
2. Add Stream Tracer. 
3. Change Seed Type to Point Source.
4. Uncheck Show Sphere. Show Sphere
5. 
6. From the quick launch, select Tube
7. 

Getting Fancy

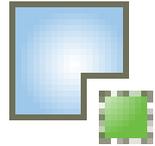
8. Select StreamTracer1.
9. Add Glyph filter. 
10. Change Glyph Type to Cone.
11. Change Orientation Array and Scale Array to V.
12. Change Vector Scale Mode to Scale By Magnitude.
13. Click reset  next to Scale Factor.
14. 
15. Color by Temp.

Reset ParaView

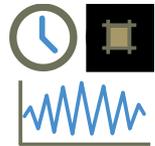
Edit → Reset Session



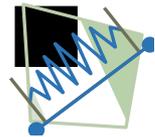
Common Data Analysis Filters



Extract Selection



Plot Global Variables Over Time



Plot Over Line



Plot Selection Over Time



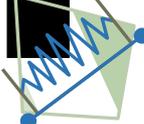
Probe Location

Plotting

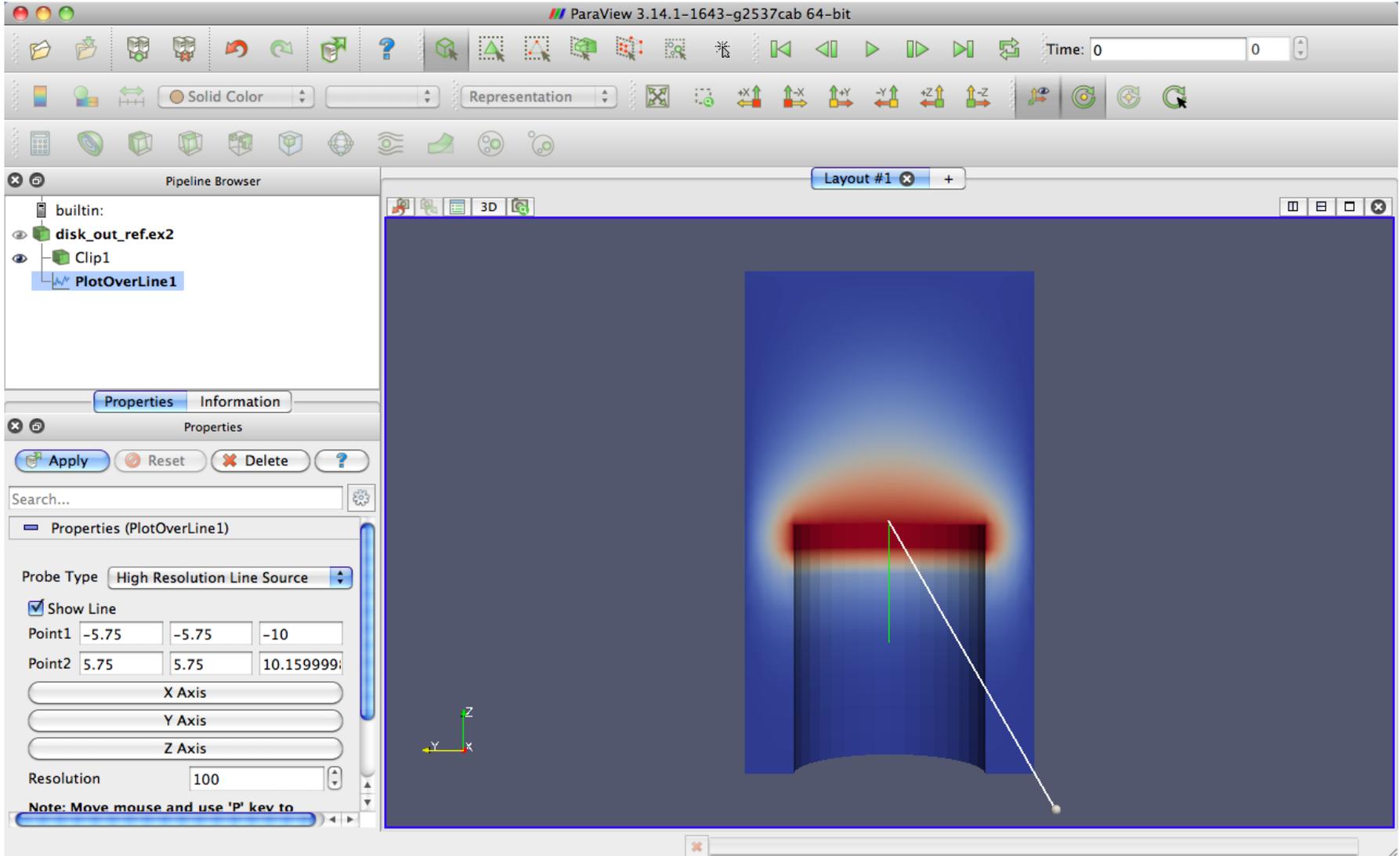
1. Open disk_out_ref.ex2. Load all variables. 

2. Clip,  uncheck, Show Plane , 

3. Select disk_out_ref.ex2.

4. Add Plot Over Line filter. 

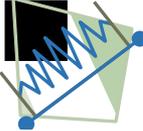
3D Widgets



Placing 3D Line Widget Endpoints

- Use the p key to place alternating points.
 - Ctrl+p places at nearest mesh point.
- Use the 1 or 2 key to place the start or end point.
 - Ctrl+1 or Ctrl+2 places at mesh point.
- Drag the endpoints.
 - Use x, y, or z key to constrain to axis.
- Use widgets in Properties panel
 - E.g. Use Z Axis button and then edit points to place from (0,0,0) to (0, 0, 10).

Plotting

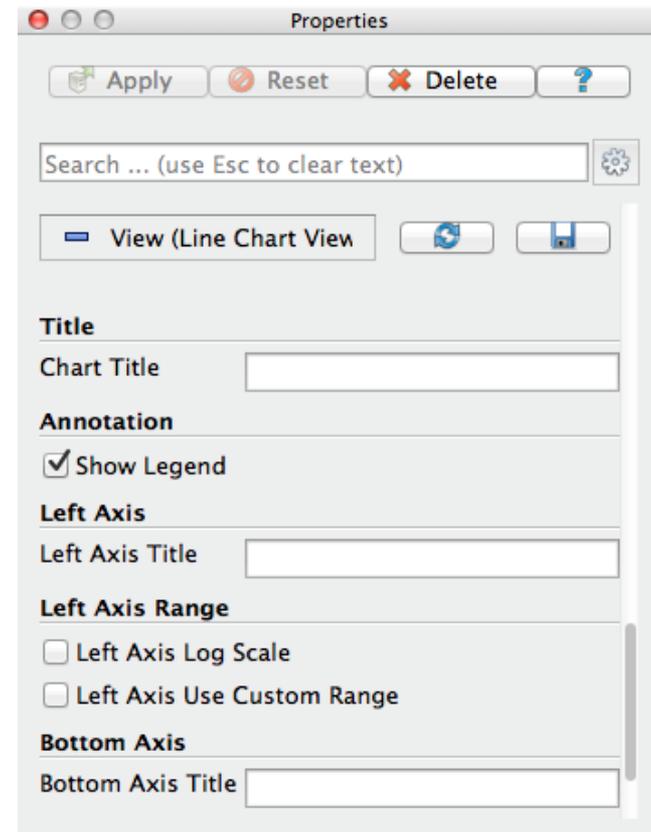
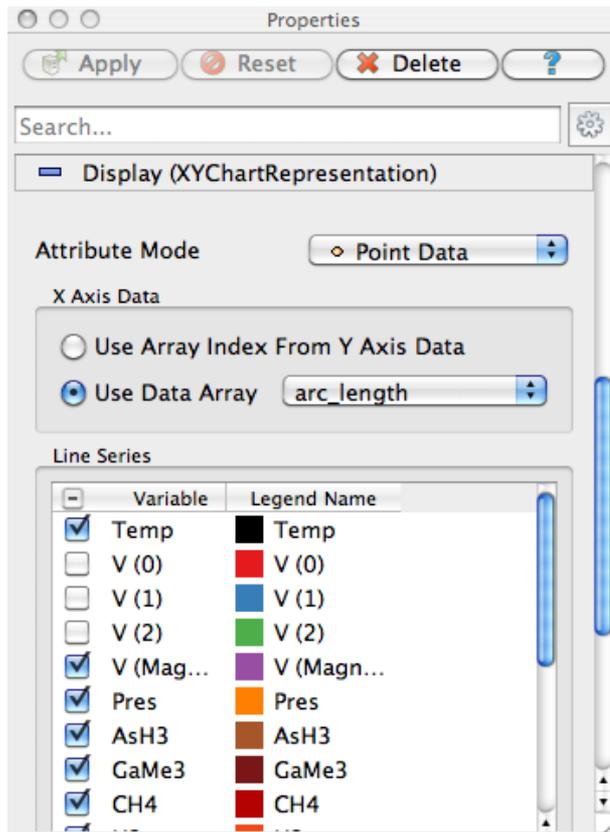
1. Open disk_out_ref.ex2. Load all variables. 
2. Clip,  uncheck, Show Plane , 
3. Select disk_out_ref.ex2.
4. Add Plot Over Line filter. 
5. Once line is satisfactorily located, 

Interacting with Plots

- Left, middle, right buttons to pan, zoom.
- Mouse wheel to zoom.
- Reset view to plot ranges. 

Plots are Views

- Move them like Views.
- Save screenshots.



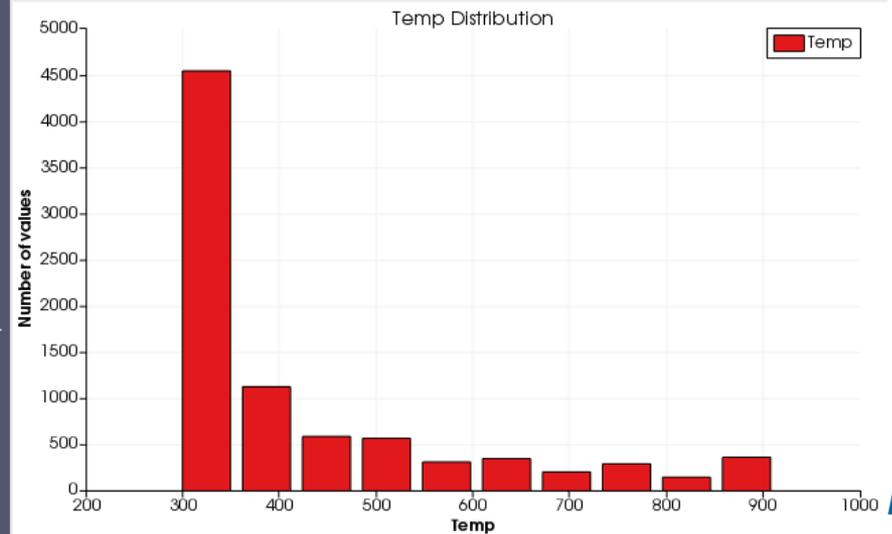
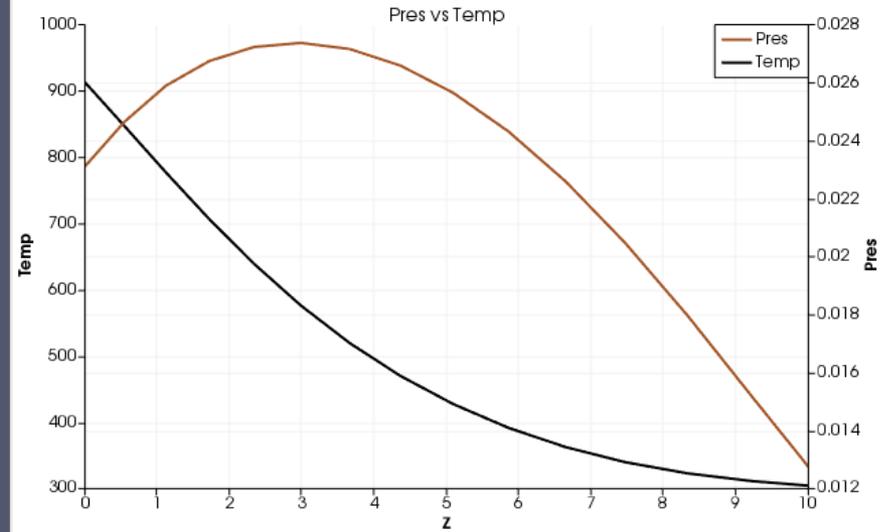
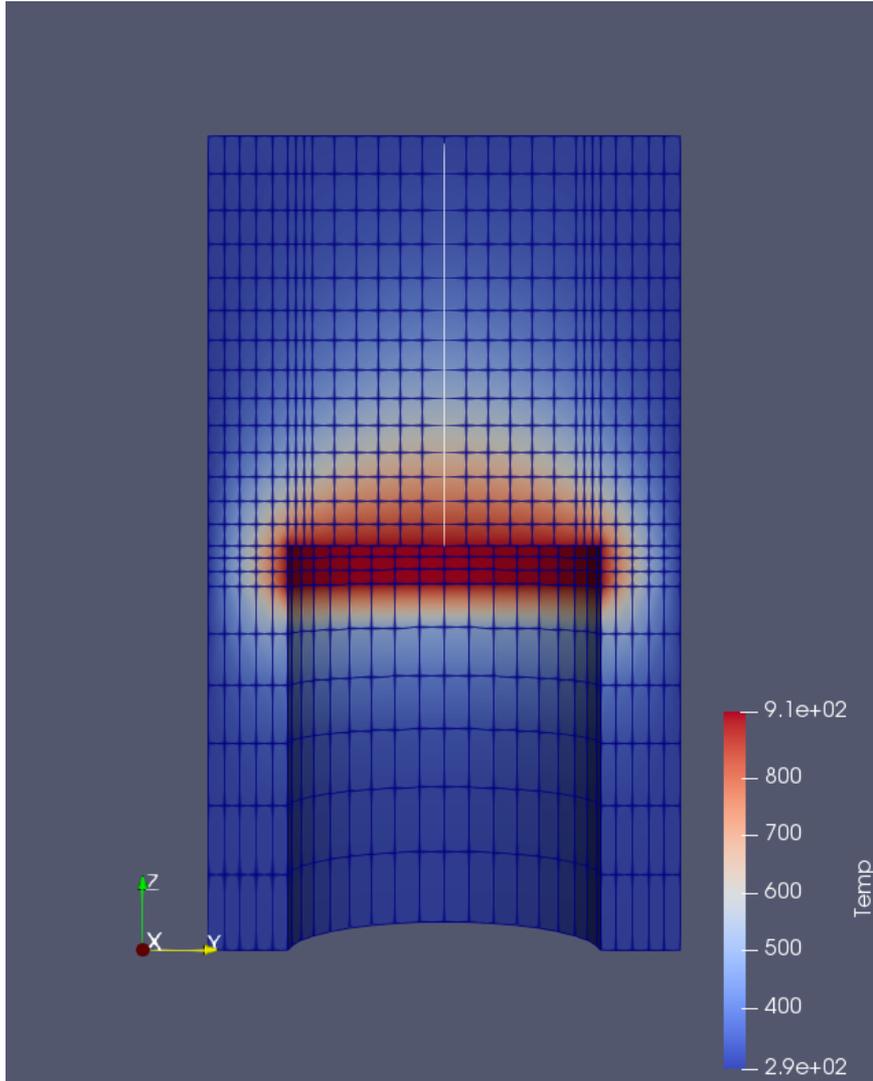
Adjusting Plots

1. In Display section of properties panel, turn off all variables except Temp and Pres.
2. Select Pres in the Display options.
3. Change Chart Axis to Bottom – Right.
4. Verify the relationship between temperature and pressure.

Histogram / Bar Chart

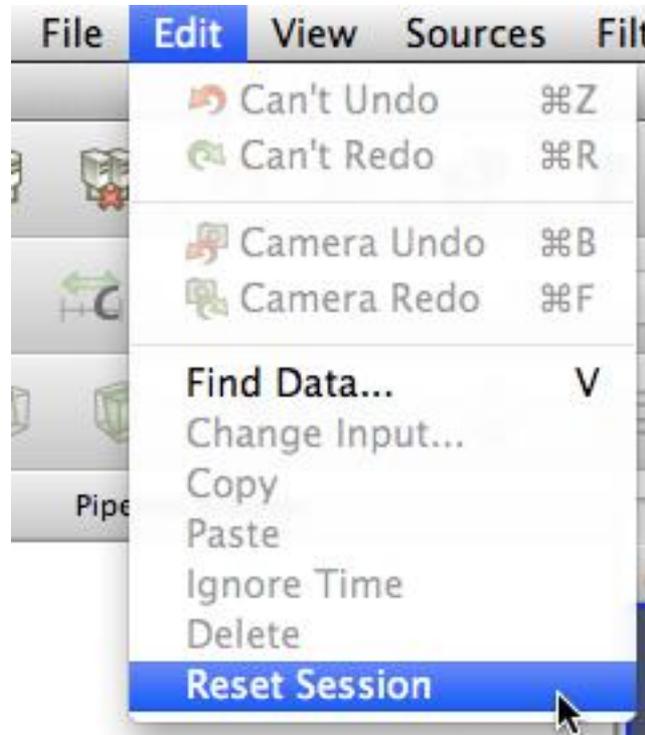
1. Select disk_out_ref.ex2.
2. Filters → Data Analysis → Histogram 
3. Change Input Array to Temp.
4. 

Histogram / Bar Chart



Reset ParaView

Edit → Reset Session



Volume Rendering

1. Open disk_out_ref.ex2. Load all variables. A blue rectangular button with a white border, containing a small icon of a document with a green checkmark and the word "Apply" in a sans-serif font.
2. Change variable viewed to Temp.
3. Change representation to Volume.
4. In the Are you Sure dialog box, click Yes.

Volume Rendering + Surface Geometry

1. Open disk_out_ref.ex2. Load all variables. 
2. Change variable viewed to Temp.
3. Change representation to Volume.
4. Add Stream Tracer.  
5. Optional: Add Tubes and Glyphs.

Transfer Function Editor

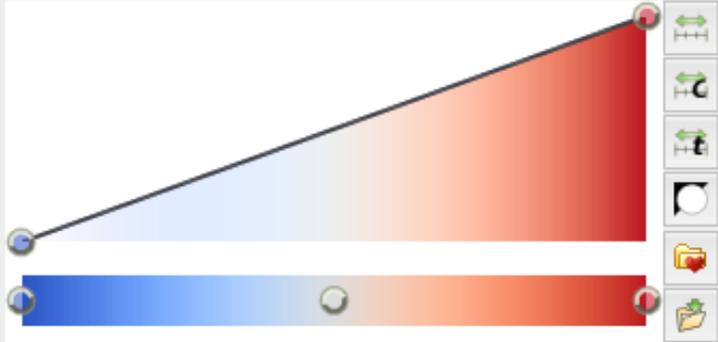


Color Map Editor

⚙️
🌈
📄

Interpret Values As Categories

Mapping Data



↕️
↕️
↕️
⬤
📁
📁

Data:

Use log scale when mapping data to colors

Enable opacity mapping for surfaces

Automatically rescale transfer functions to fit data

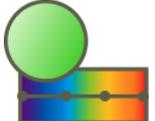
Color Mapping Parameters

Color Space Diverging

Nan Color ●

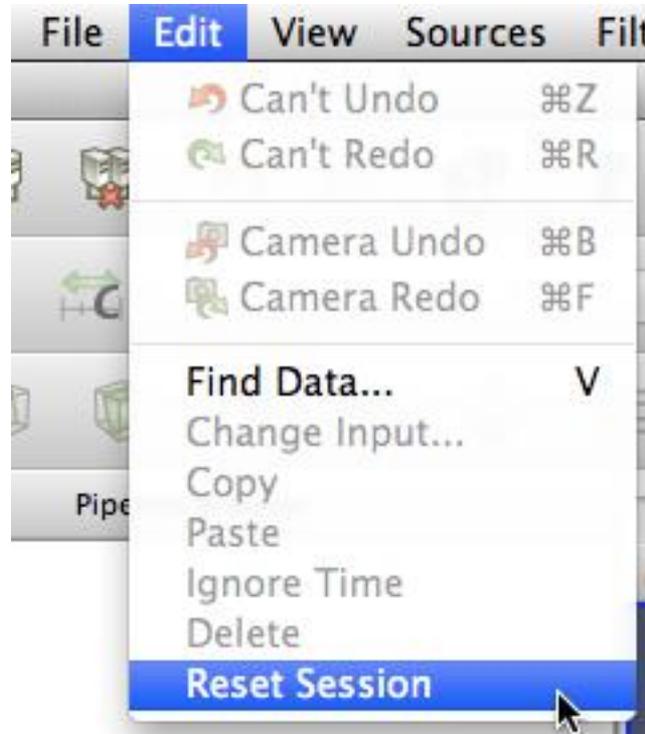
Save as default
🔄 Update
🔄

Modify Transfer Function

1. Select disk_out_ref.ex2.
2. Click Edit Color Map .
3. Click Choose preset .
4. Select Black-Body Radiation.
Apply. Close.
5. Try adding and changing control points.

Reset ParaView

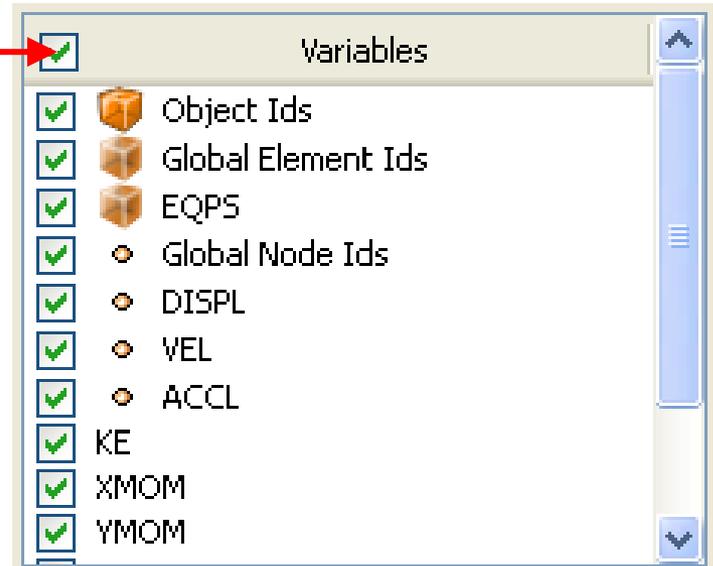
Edit → Reset Session



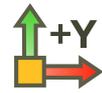
Loading Data with Time

1. Open the file can.ex2.

2. Select all variables.



3.  Apply

4. 

5. 

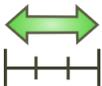
Animation Toolbar



Animation Pitfall

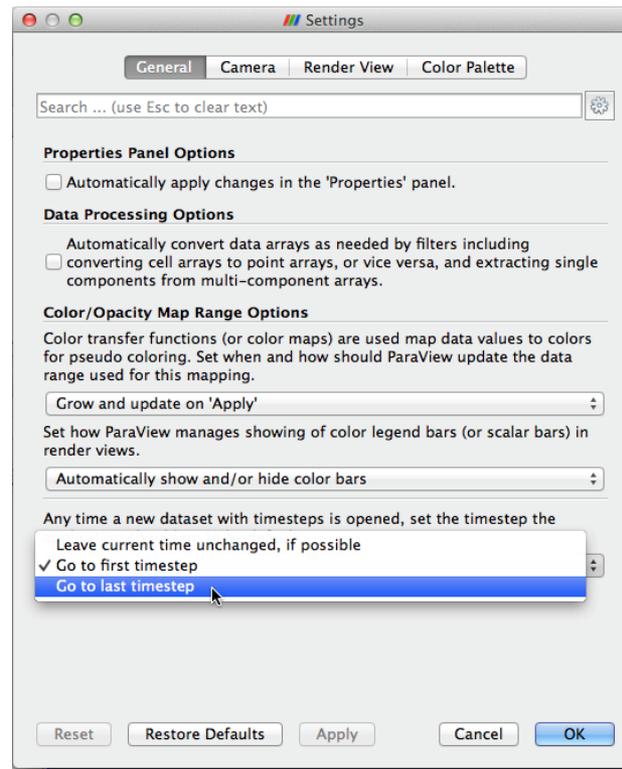
1. Go to first time step. 
2. Color by EQPS variable.
3. Play  (or skip to last time step ).

Animation Pitfall

1. Go to first time step. 
2. Color by EQPS variable.
3. Play  (or skip to last time step ).
4. Fix with Rescale to Data Range. 

Data Range Workarounds

- Go to representative time and hit 
- In Settings change On File Open to Goto last timestep.



Data Range Workarounds

- Set a custom range.

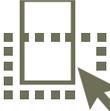


Data Range Workarounds

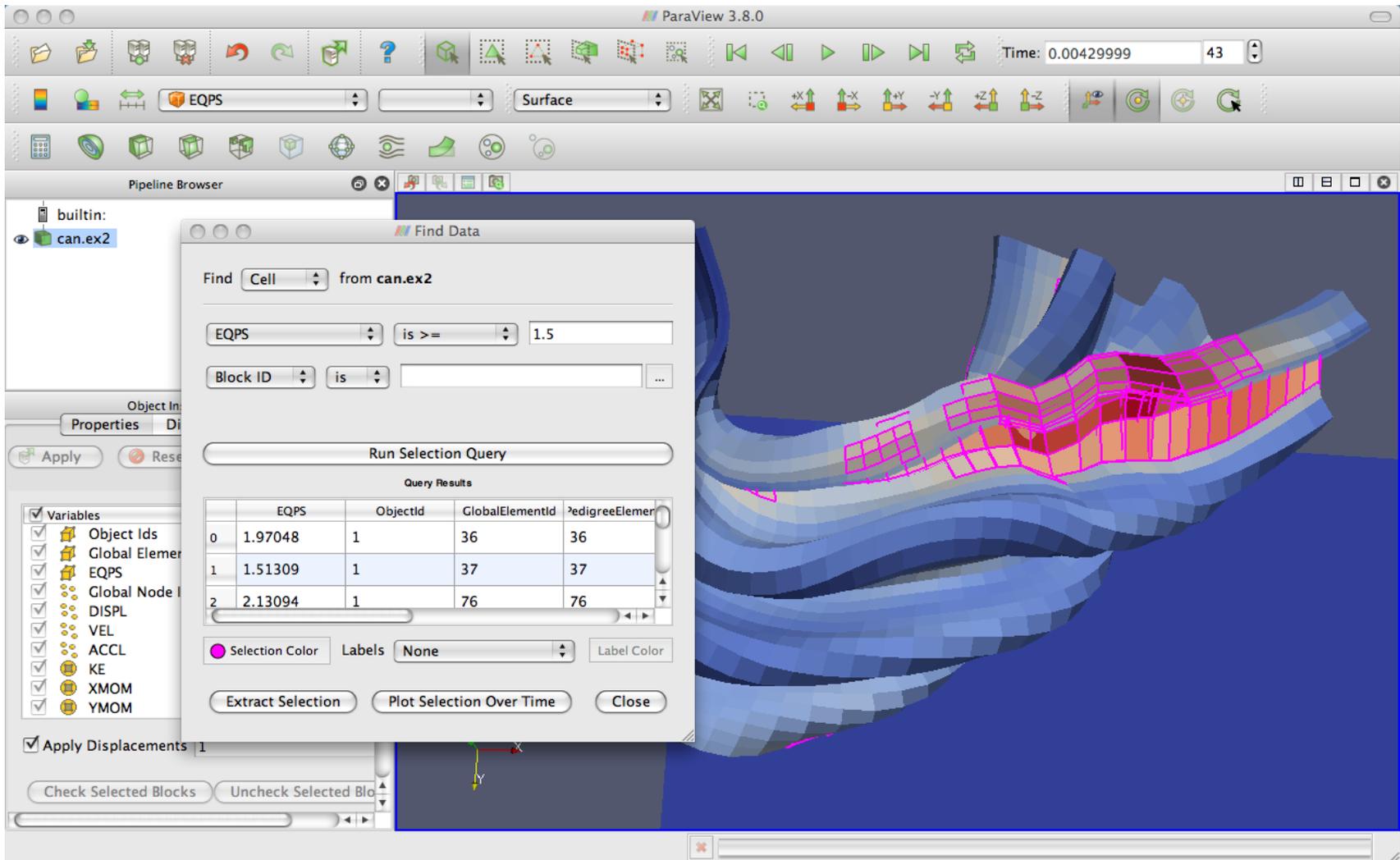
- Rescale to range over all timesteps



Query-Based Selection

1. Open can.ex2. All variables. 
2. Go to last time step. 
3. Edit → Find Data. 
4. Top combo box: find Cells.
5. Next row: EQPS, is \geq , and 1.5.
6. Click Run Selection Query.

Query-Based Selection



ParaView 3.8.0

Time: 0.00429999 43

EQPS Surface

Pipeline Browser

- builtin:
 - can.ex2

Object Inspector

Properties Display

Apply Reset

Variables

- Object Ids
- Global Elements
- EQPS
- Global Node Ids
- DISPL
- VEL
- ACCL
- KE
- XMOM
- YMOM

Apply Displacements 1

Check Selected Blocks Uncheck Selected Blocks

Find Data

Find **Cell** from **can.ex2**

EQPS is >= 1.5

Block ID is

Run Selection Query

Query Results

	EQPS	ObjectId	GlobalElementId	PedigreeElement
0	1.97048	1	36	36
1	1.51309	1	37	37
2	2.13094	1	76	76

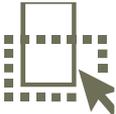
Selection Color Labels None Label Color

Extract Selection Plot Selection Over Time Close

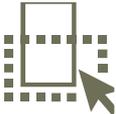
Brush Selection

- 
Surface Cell Selection
(shortcut: s)
- 
Surface Point Selection
(shortcut: d)
- 
Through Cell Selection
(shortcut: f)
- 
Through Point Selection
(shortcut: g)
- 
Select Cells (polygon)
- 
Select Points (polygon)
- 
Block Selection
(shortcut: b)
- 
Interactively Select Cells
- 
Interactively Select Points
- 
Hover Point Query
- 
Hover Cell Query

Adding Labels

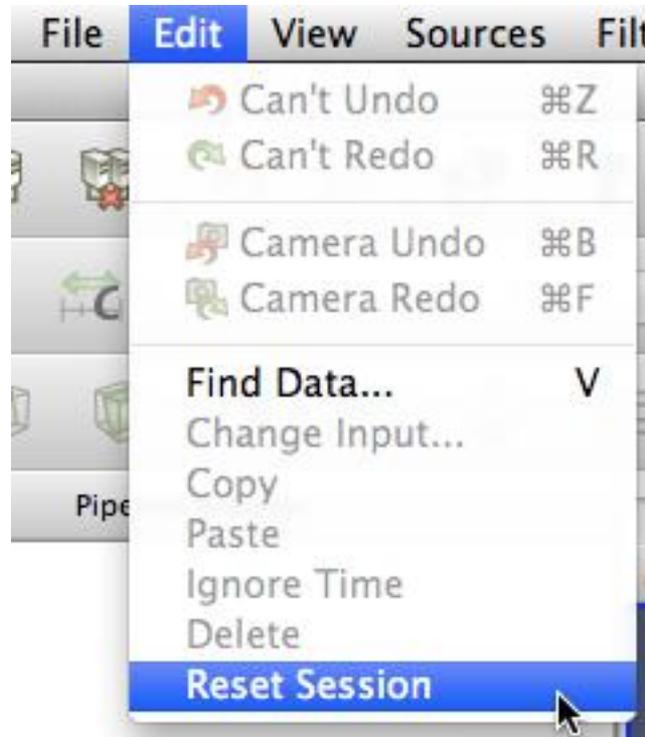
1. Go to the last time step. ▶▶
2. Open Find Data. The icon for the Find Data tool, which is a square with a dotted border and a mouse cursor pointing to the bottom-right corner.
3. Create query Global ID is min. Click Run Selection Query.
4. In the Cell Labels chooser, select EQPS.

Adding Labels

1. Go to the last time step. ▶▶
2. Open Find Data. 
3. Create query Global ID is min. Click Run Selection Query.
4. In the Cell Labels chooser, select EQPS.
5. When you are done, turn off the EQPS labels.

Reset ParaView

Edit → Reset Session



Python Scripting

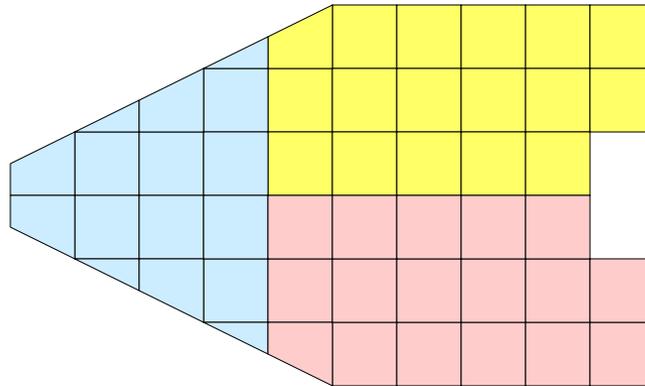
- Tools > Start Trace
- Build visualization pipeline with UI
- Tools > End Trace
- Save Python script



Visualizing Large Models

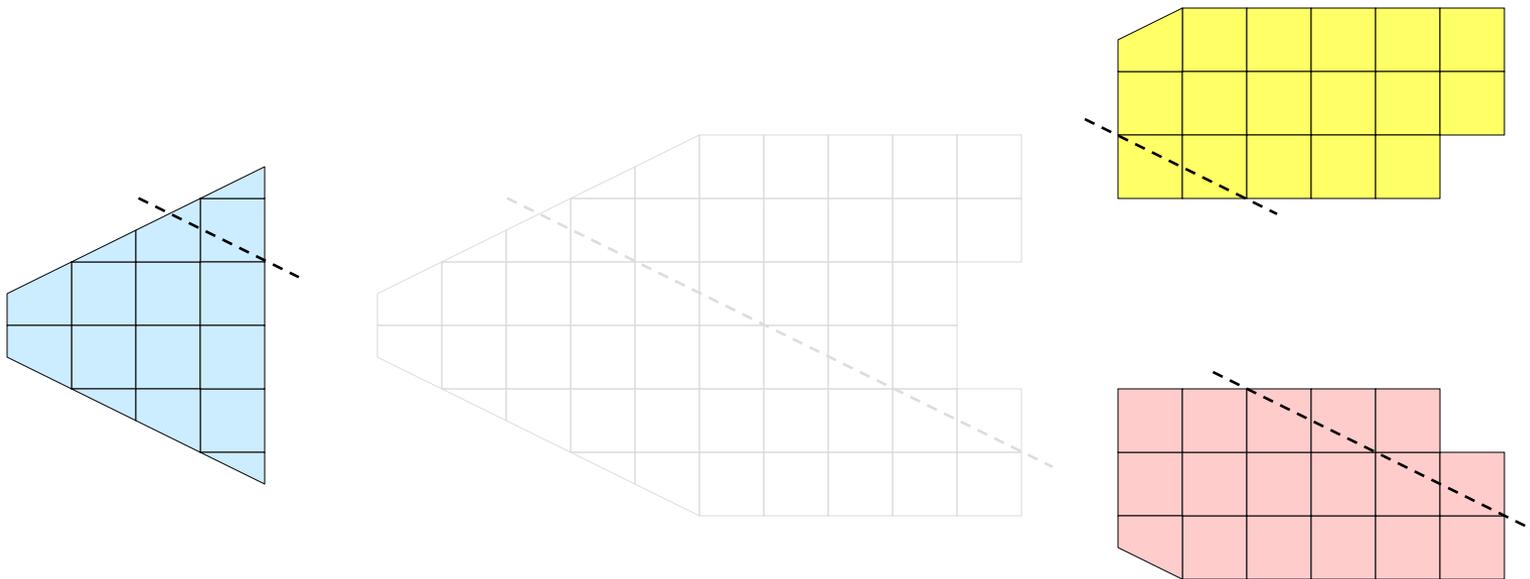
Data Parallel Pipelines

- Duplicate pipelines run independently on different partitions of data.



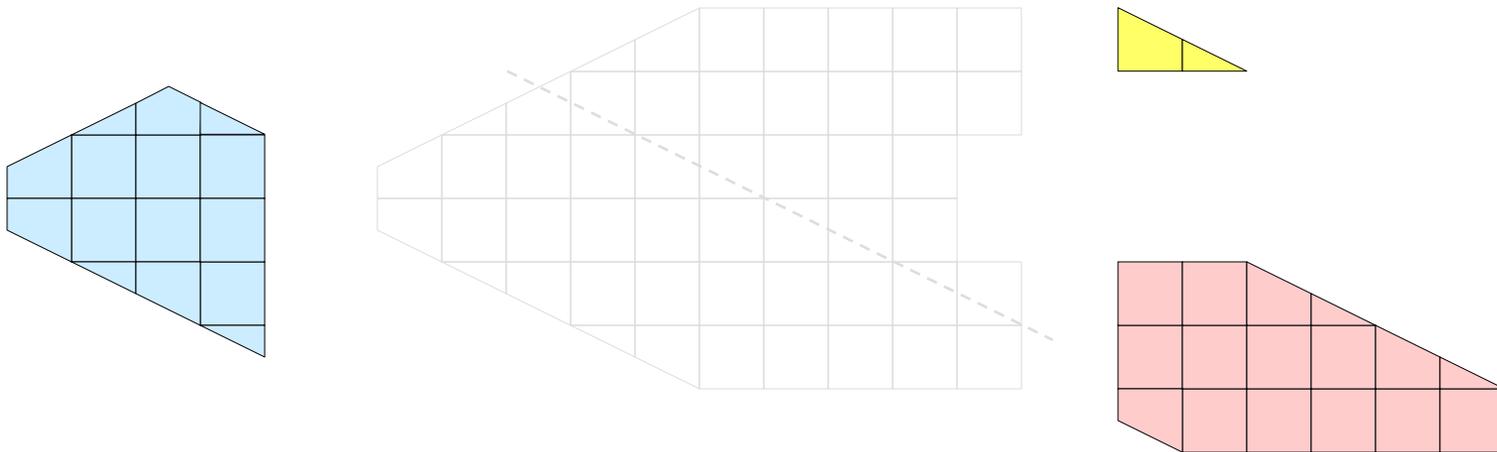
Data Parallel Pipelines

- Many operations will work regardless.
 - Example: Clipping.



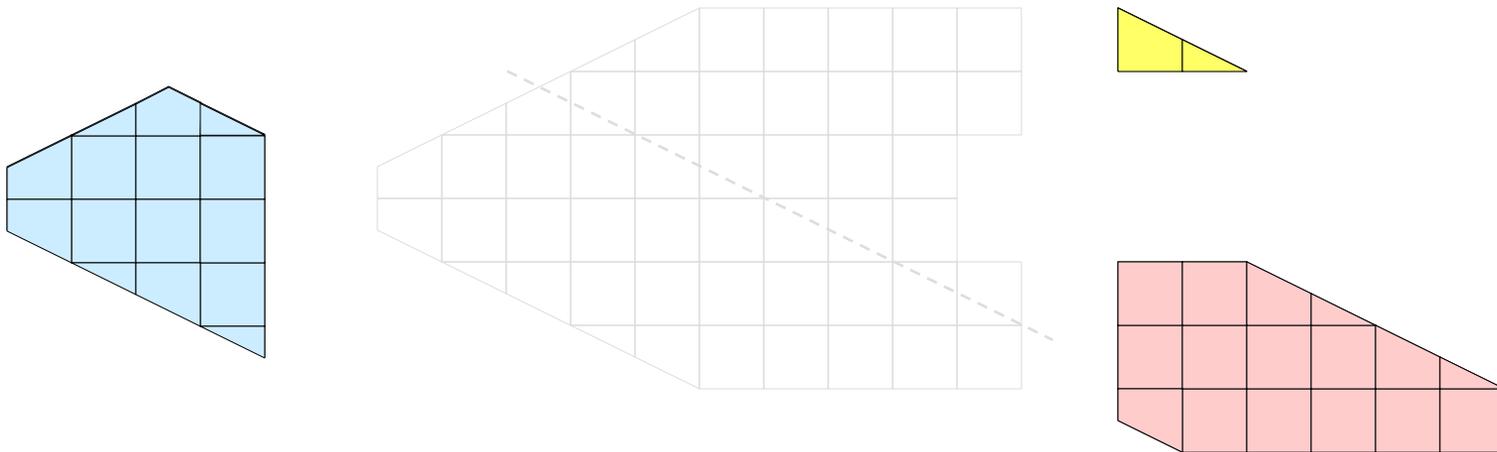
Data Parallel Pipelines

- Many operations will work regardless.
 - Example: Clipping.



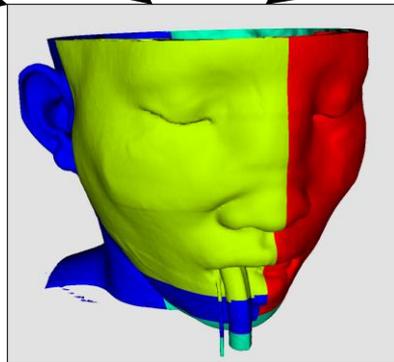
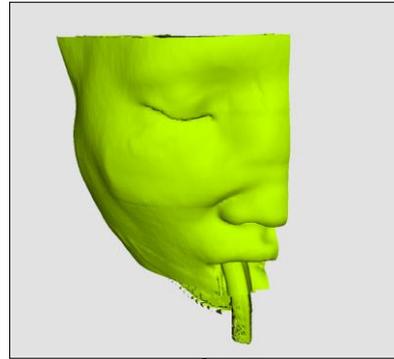
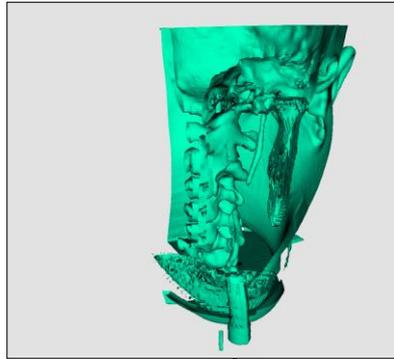
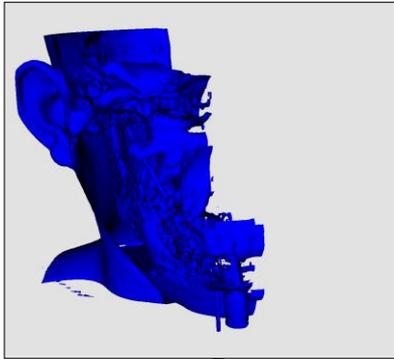
Data Parallel Pipelines

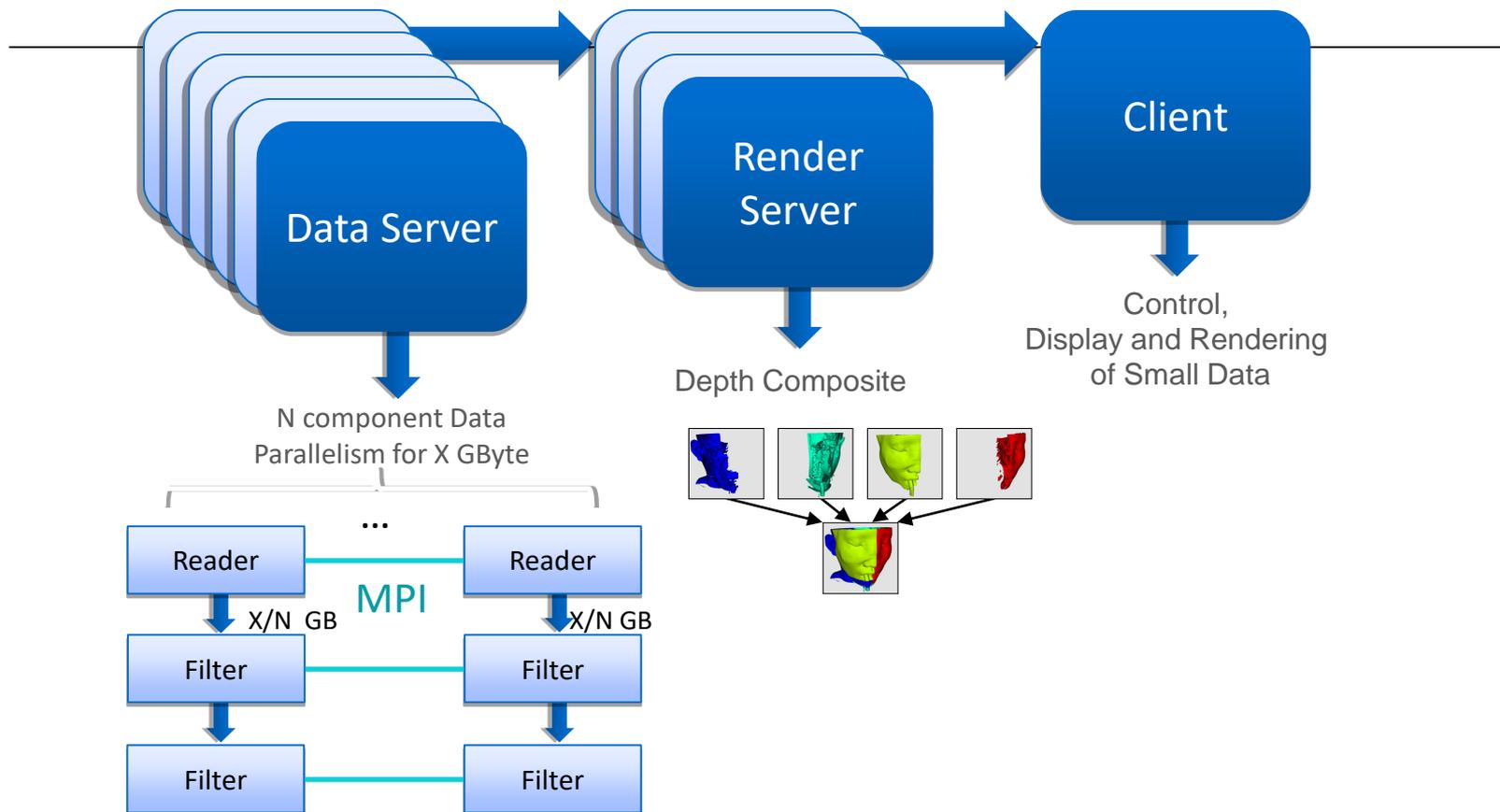
- Many operations will work regardless.
 - Example: Clipping.



- Will discuss those that don't later

Parallel Rendering





ParaView's Running Modes

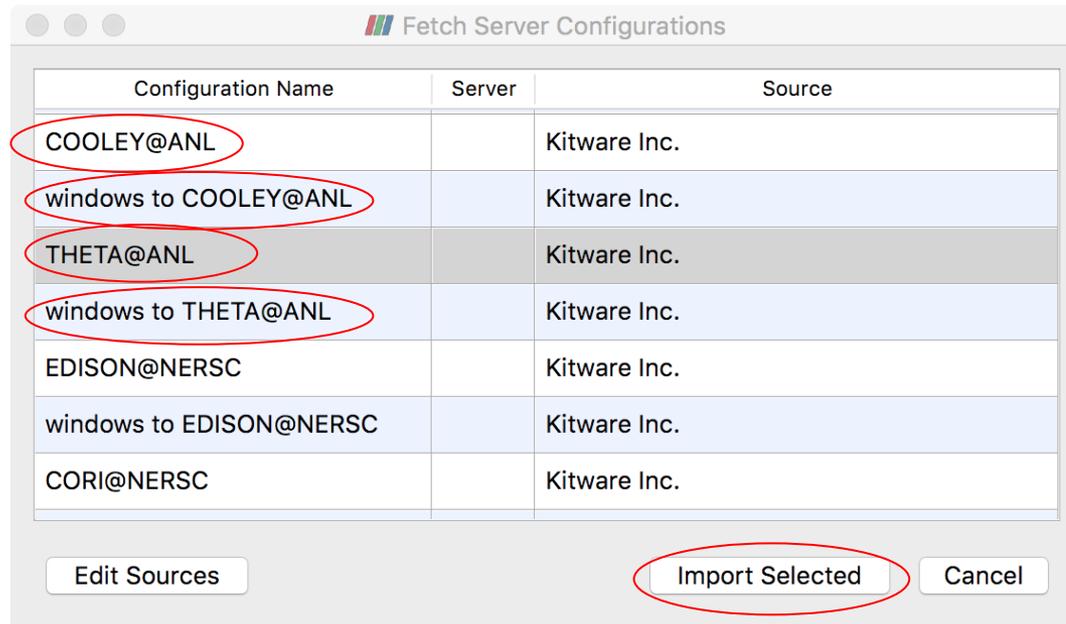
<p>Builtin aka Standalone aka Serial</p>		<p>all components within one process (client may be GUI or pvpython) <code>paraview pvpython</code></p>
<p>Combined Server</p>		<p>data processing and parallel rendering in MPI job of combined processes. control from TCP connected client. <code>mpiexec -n x pvserver & paraview # or pvpython #+Connect</code></p>
<p>Batch</p>		<p>server is an MPI job which directly runs a python script <code>mpiexec -n x pvbatch \ vis_script.py</code></p>

DS = data server

RS = render server

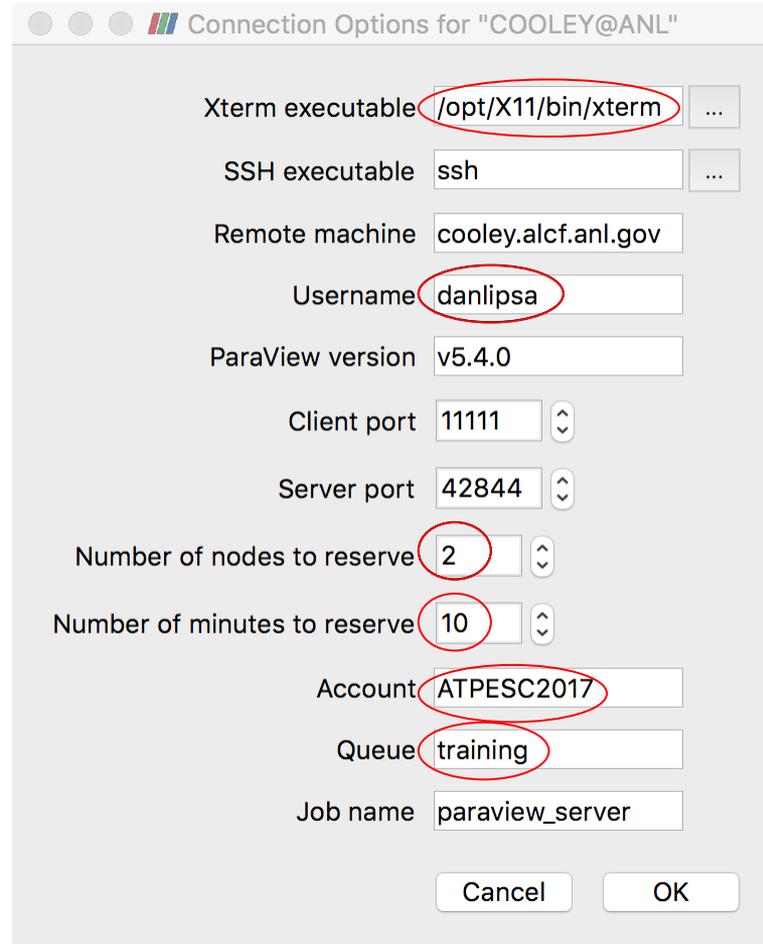
Fetch Server Configuration

- File > Connect > Fetch Servers



Connect Unix/Mac

Mac Os: Install Xquartz

A screenshot of the "Connection Options for 'COOLEY@ANL'" dialog box in ParaView. The dialog has a title bar with three window control buttons and the text "Connection Options for 'COOLEY@ANL'". The main area contains several fields and controls:

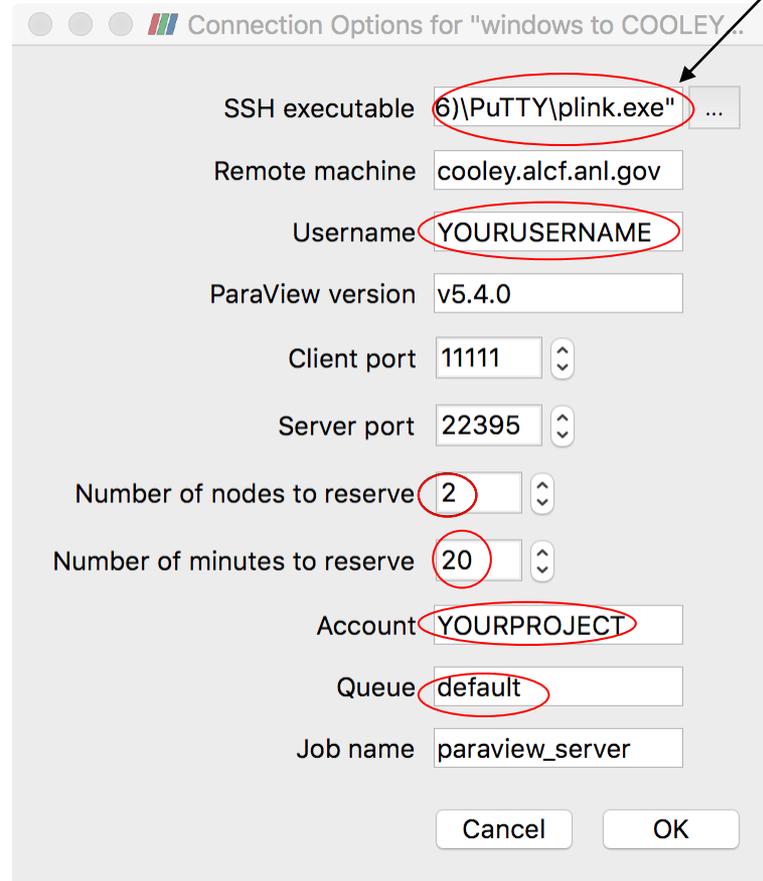
- Xterm executable: (circled in red)
- SSH executable:
- Remote machine:
- Username: (circled in red)
- ParaView version:
- Client port: with up/down arrows
- Server port: with up/down arrows
- Number of nodes to reserve: with up/down arrows
- Number of minutes to reserve: with up/down arrows
- Account: (circled in red)
- Queue: (circled in red)
- Job name:

At the bottom right, there are "Cancel" and "OK" buttons.

Connect Windows

quotes are required

Windows: Install PuTTY



Connection Options for "windows to COOLEY"

SSH executable

Remote machine

Username

ParaView version

Client port

Server port

Number of nodes to reserve

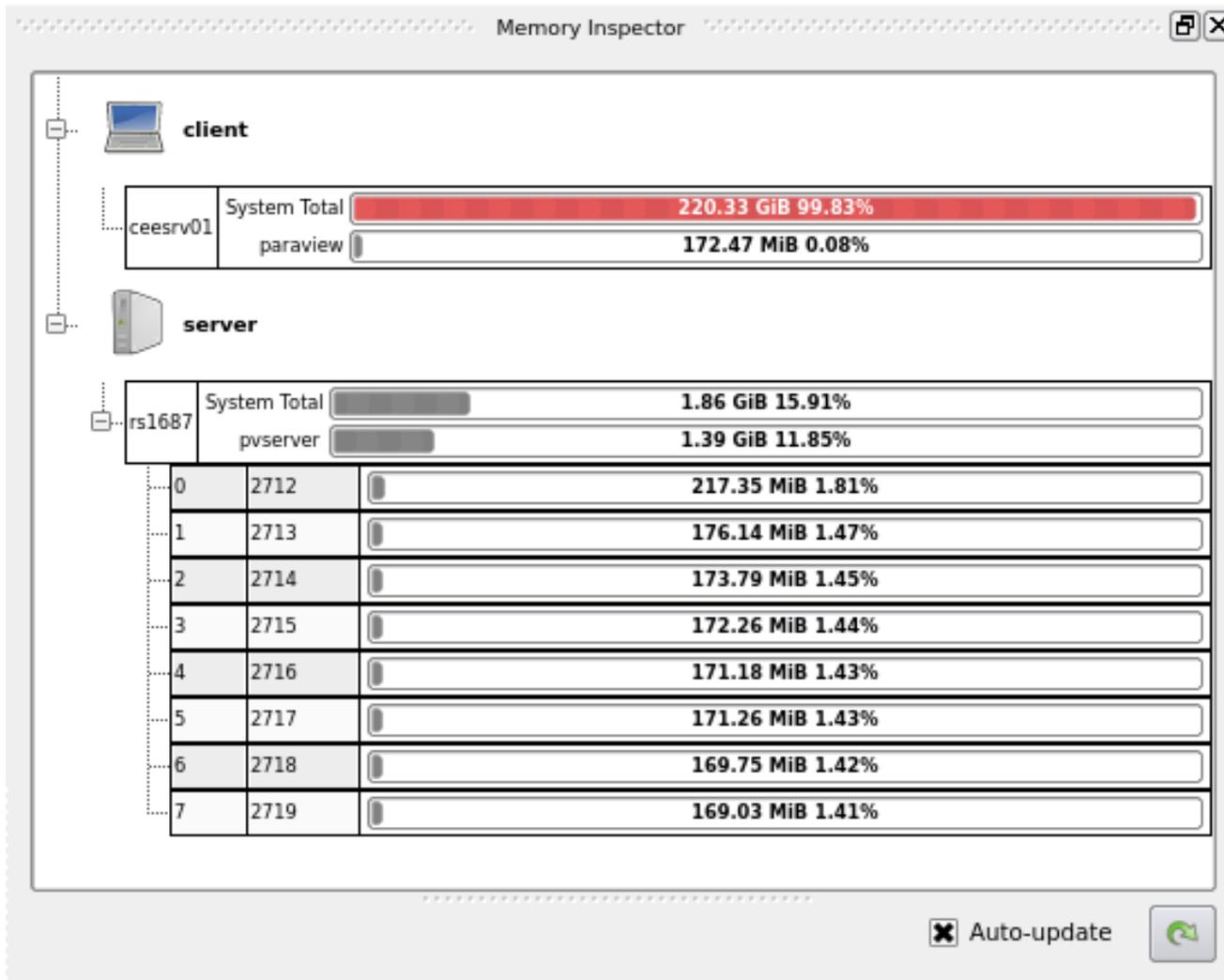
Number of minutes to reserve

Account

Queue

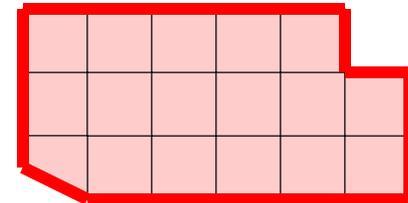
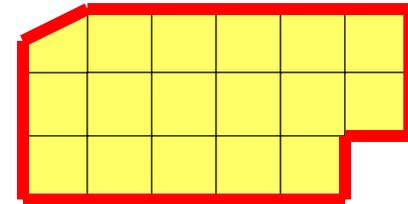
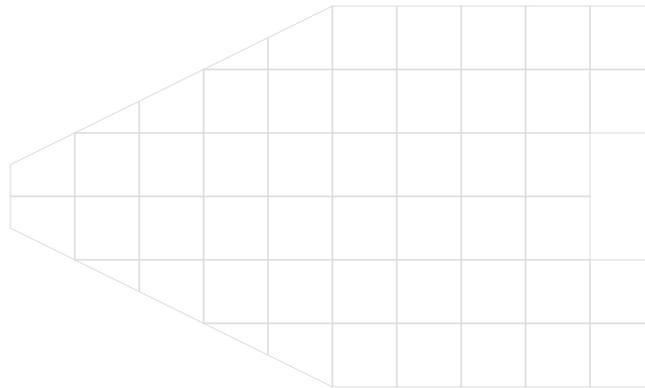
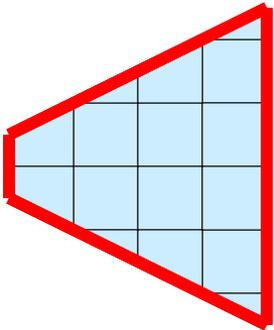
Job name

Memory Inspector



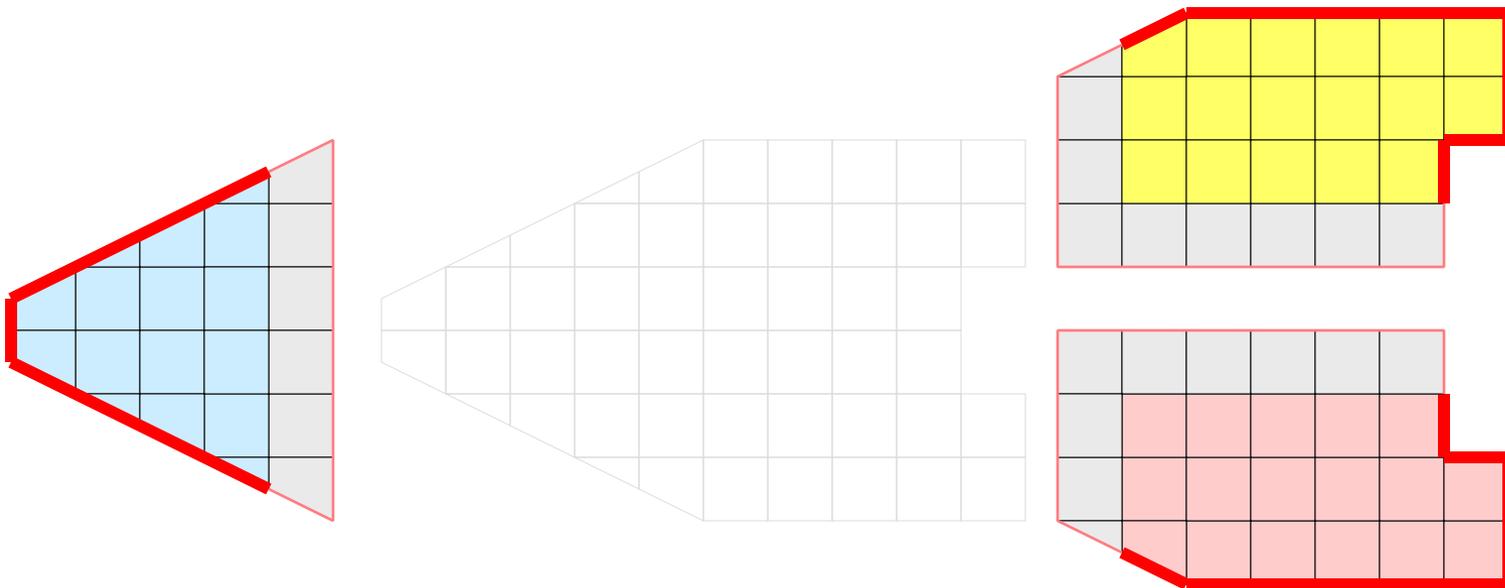
Advanced Data Parallel Pipelines

- Some operations will have problems.
 - Example: External Faces



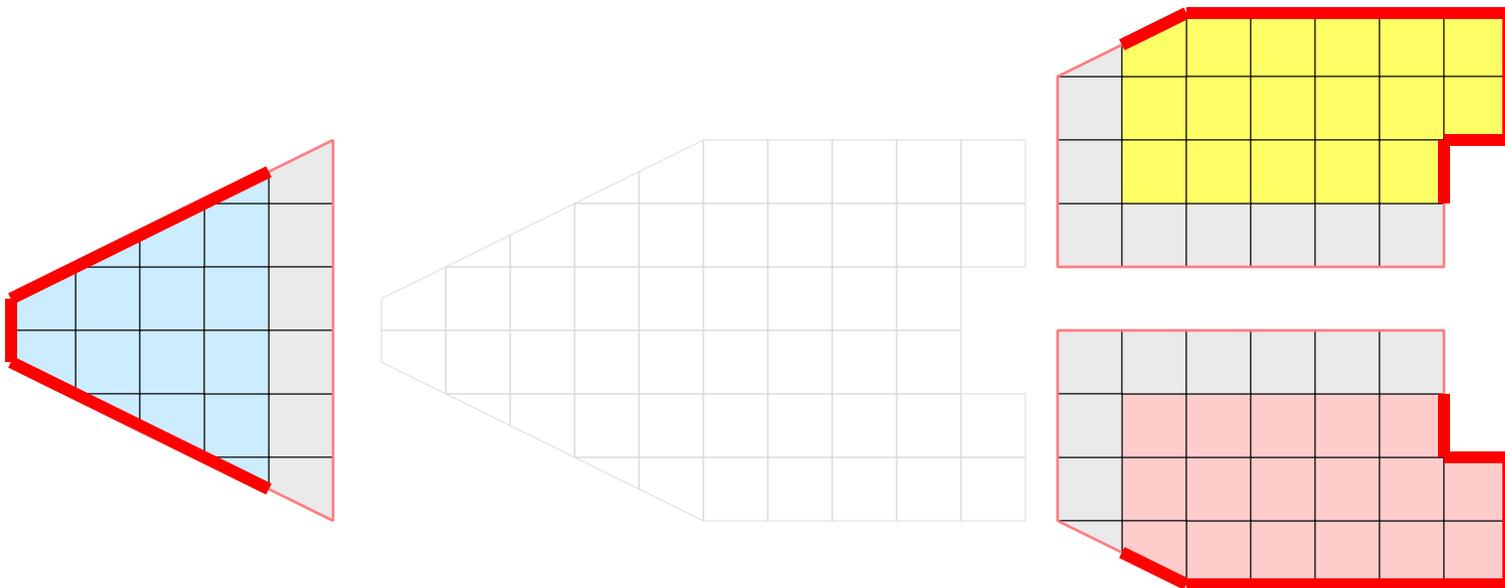
Advanced Data Parallel Pipelines

- Ghost cells can solve most of these problems.



Advanced Data Parallel Pipelines

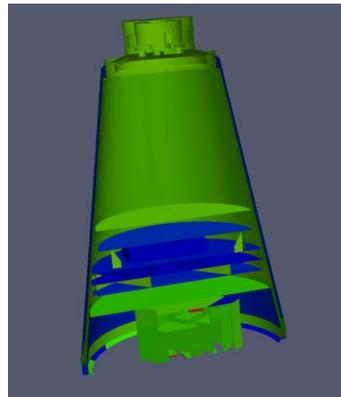
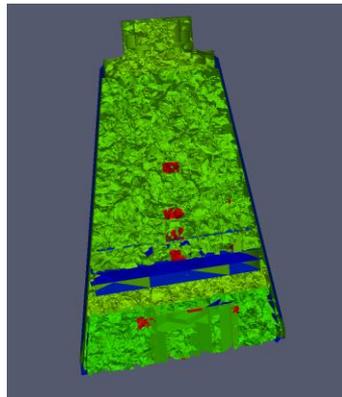
- Ghost cells can solve most of these problems.



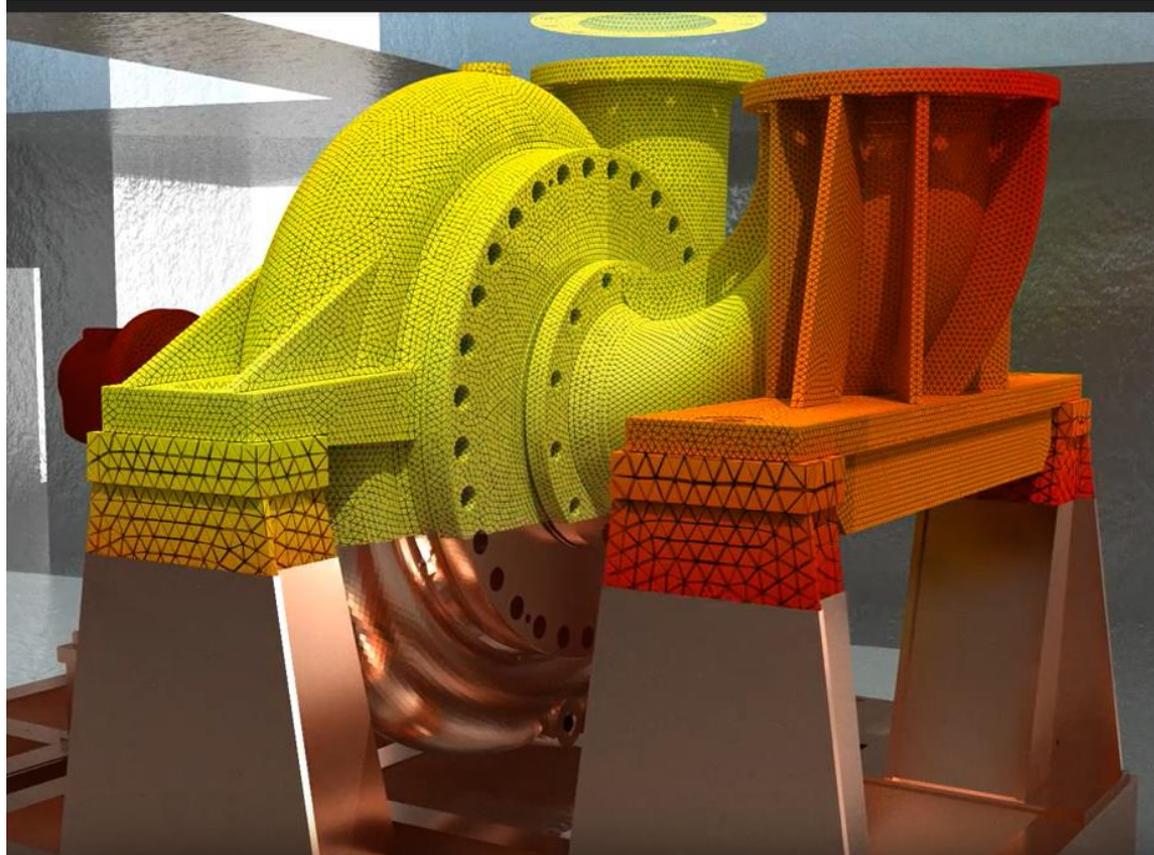
Balanced Partitioning + Ghost Cells

- Automatic when reading structured data.
- For unstructured data:
 - Ghost Level Generator: creates ghost cells (if data is partitioned on disk)
 - D3: also creates a balanced partition.

Extract Surface
without ghost
cells



Extract Surface
after D3



Thank you!
Questions?